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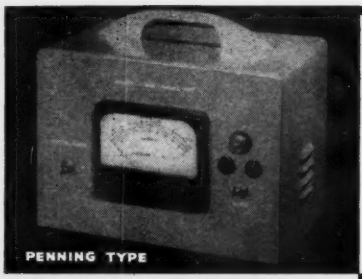

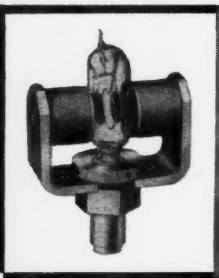

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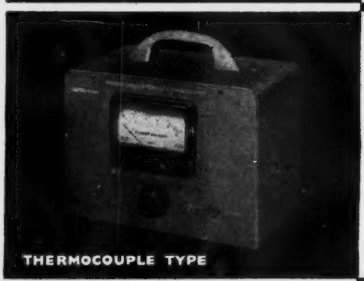

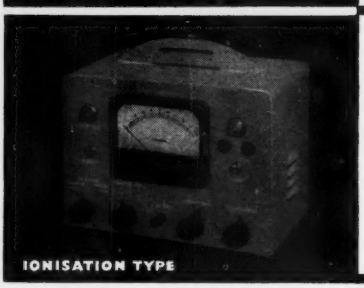

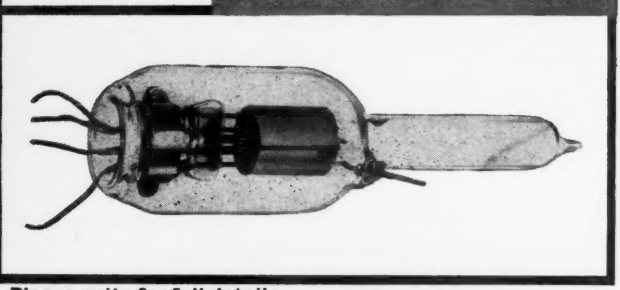

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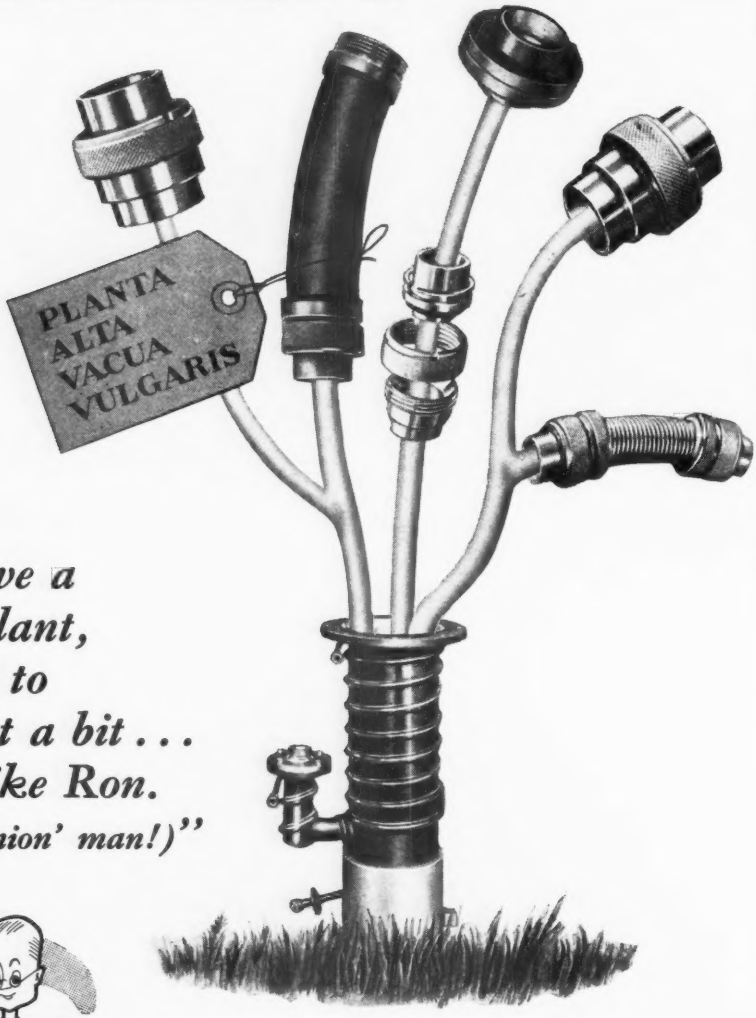

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MANAGEMENT PROBLEMS IN UNDER-DEVELOPED COUNTRIES

IN a recent broadsheet which reviewed the prospects for nuclear power, Political and Economic Planning referred to the potential market in under-developed territories for a small reactor similar to that for modestly powered gas-turbine and diesel-driven generating sets. Such a reactor, if cheap, with the advantages that it can be sited where the power is needed and its fuel requirements are small, with the consequent elimination of transmission lines and high fuel transport cost, could transform areas at present undeveloped or unexploited. Whether such reactors will actually help to raise the standard of living of millions of people who are now forced to do with little or no power and to rely on inefficient fuel burning, or human labour or on animals, does not depend entirely, however, perhaps even primarily, on the ability of the scientists and technologists of the United States, Britain or the U.S.S.R.—the only three countries at present able to provide nuclear reactors for export, the knowledge of how to work them and the necessary instrumentation and servicing—to design and manufacture such a reactor at a low enough price. It depends at least as much on the provision of efficient management in the countries where the reactors are to be used.

This aspect of technical assistance has not been entirely overlooked in earlier discussions of that broad problem, but Political and Economic Planning has now examined its implications more fully in a further broadsheet, "Management and Under-developed Territories" (No. 434, June 1, 1959)*. The broadsheet is indeed primarily concerned with the problems which confront expatriate firms already operating in such countries, one after another of which are insisting that such firms must bring local nationals into their managerial and technical staff. Technically qualified nationals, however, have been very hard to find, both for lack of local technical education and for lack of the basic education necessary to acquire technical qualifications. In principle, management positions were open to anyone capable of filling them, but in practice Europe and North America have been the only sources of supply.

The broadsheet emphasizes the close connexion between political and economic factors in the under-developed territories; but to the scientist and technologist it is of special interest for its analysis of the way in which Western firms established in such countries have sought to meet this demand and of the phases of their consequent staffing policy. Factors are emphasized which should be noted by those who proceed to such countries under schemes of technical aid, no less than by those who enter the service of expatriate firms. Particularly is this true of the concluding section of the broadsheet, which discusses the influence of the political climate in such countries and the attitude that is adopted towards Western institutions and ways of doing things. The main assumption on which Western aid to the poorer countries has so far been based—that, if enough technical knowledge and capital are injected into a country which is very deficient in both, it is on the way to becoming rich and developed—is frankly challenged.

The shortage of educational and training facilities in under-developed countries, especially in Africa, has led many firms to set up their own; but this has meant both finding young men capable and willing to attend courses of higher education, and persuading young men already receiving higher education in local or European universities that the opportunities genuinely exist. Competition for the talent available locally is keen and sometimes the supply of young men of good calibre is limited by the practice of requiring scholarship holders to enter government service for a period. Moreover, a man not fully trained to the standards of a Western concern may be, by local standards, fully equipped for a senior post.

The broadsheet naturally does not enter into the problems of promotion policy which can easily arise, but these possibilities of friction have to be considered in framing a staffing policy and they are not diminished where race and class form the basis of politics, as they do now to a large extent in under-developed countries. Political pressure towards nationalization, in the sense of increasing the proportion of nationals employed, may not allow the time required to determine a wise staffing policy and to build up a tradition of fundamental values of honesty, truthfulness and loyalty, which like the readiness to assume responsibility may require to be nurtured and strengthened in different countries in different ways. While a necessary minimum of academic knowledge may be demanded of scientific or technical staff, it would be wrong to expect the same response from the graduates of such countries as from their European counterparts. Some allowance must be made for the local environment.

Nor is it simply a matter of adapting an organization to its environment. Changes in management technique may be required, and care should be taken that expatriate staff who are selecting, training and working with 'national' colleagues develop their own powers of understanding at least to the extent of being able to comprehend the mental processes of such colleagues, to assess justly their character and ability, and to assist them in their difficulties of adjustment to their job and to their European colleagues. Moreover, as *Planning* points out, the emergence of common problems of development and the disparities in supplies of trained men between countries, and the need for the parent company to keep in close touch

*_Planning_, Vol. 24, No. 434 (1 June, 1959): Management and Underdeveloped Territories. Pp. 113–130. (London: Political and Economic Planning, 1959.) 2_s._ 6_d._

with the problems of local companies, encourage the development of a managerial staff with wide experience outside their own countries; and this widening of opportunities for men of all races to reach positions of responsibility will probably place a practical limit upon the employment of nationals as such in any one local company.

Summarizing the stages through which the staffing policies of parent firms have passed, the broadsheet notes that up to the Second World War, overseas firms were staffed largely by expatriates, who generally made careers abroad; and there was a general prejudice against business careers on the part of Western-educated nationals, even if educational facilities had been adequate for them to enter the executive ranks. This was succeeded by a phase in which national talent was created where necessary, either by internal training or by the formation or support of educational opportunities outside the firm. Now a third phase is emerging. The arrival of the locally recruited executive has coincided with—and is partly responsible for—the rapid disappearance of the expatriate career, as distinct from the job, abroad. Now, at least among the international concerns, staffing policy is developing along the lines of equipping management with international, rather than national, experience.

The aim of this policy is to obtain a greater cross-fertilization of ideas through an extensive system of overseas postings during the development of the career of an executive. The concept of an expatriate career is being eliminated by offering jobs abroad as an integral part of management training and promotion. This new type of policy should not only improve the quality of management but also contribute to greater adaptability. It clearly has implications in respect of education for management in Britain, and although it should ensure that on the Western side the weakness of rigidity is avoided, it should also be remembered that rigidity is equally dangerous where nationalism is encouraged.

It is here that the broadsheet, referring to Turkey and Iraq as examples, challenges the assumption that technical aid, applied in Western manner through institutions of Western style, can alone provide all that is needed, and quotes in support Mr. M. Ionides's recent address, "Technical Aid: the Role of the West", to the Royal Institute of International Affairs. Western institutions, Mr. Ionides argued, adapted to societies where the initiative comes from below, cannot fully satisfy the needs of a society where the flow of initiative is from the top downwards. In particular, Western institutions are not organized to tap the immense capital resources in such countries already existing in the form of unused man-power; they can only touch the fringes where a cash-economy exists.

More and more capital and technical assistance are being supplied to the centres of sophisticated Western-style economy in the under-developed countries, sharpening the contrast with the surrounding rural economy, and whetting appetites for higher standards of life. Capital investment from outside, from the top downwards, cannot fill this gap and the balance of influence of the West has so far diverted the attention of these countries from their need to help to work out their own ways of filling this gap by mobilizing the reserves of labour. Western-inspired ideas of industrialization naturally put the emphasis where the system works best; this attracts enterprise and initiative away from the much-needed widespread small-scale development. Nor does the large-scale project which the West can provide and which most governments in these under-developed territories request, because they want to develop in the Western manner, teach the simpler methods and provide the training in them that are needed or supply where it is needed the organizing ability essential for a start. It does not even provide the experience or outlook required to initiate or operate schemes which are not primarily aimed at securing profits.

This is a formidable argument, and it emphasizes the close connexion between economic and political factors in the under-developed countries. If it is correct, the assistance programmes sponsored by governments and international agencies may require extensive modification. Deficiencies there cannot be made up by goodwill or flexibility on the part of the branches of Western industry and commerce already established in those countries. Be that as it may, the prospects for the export of the small nuclear reactor should be the brighter in such a context; but the opportunities for Britain here and elsewhere will also depend on the attention given to training for management, and the quality and width of outlook and wisdom of the trained man-power which she is able to send overseas—as administrators, technologists or scientists—and whether in government or other public service or in ordinary industrial or commercial life.

CLASSICS OF NUTRITION

A History of Nutrition

The Sequence of Ideas in Nutrition Investigations. By Prof. Elmer Verner McCollum. Edited by H. Bentley Glass. Pp. x+451. (Boston, Mass.: Houghton Mifflin Company, 1957.) 6 dollars.

The Englishman's Food

A History of Five Centuries of English Diet. By the late Prof. Sir Jack Drummond and Anne Wilbraham. Revised, and with a new chapter by Dorothy Hollingsworth. Pp. 482+8 plates. (London: Jonathan Cape, Ltd., 1958.) 36*s*. net.

HERE are two volumes of outstanding interest and importance. It is not an exaggeration to say that each of them is indispensable to all serious research workers, and other students of nutrition.

E. V. McCollum, now professor emeritus of biochemistry of the Johns Hopkins University, is the doyen of nutrition authorities, pre-eminent as a pioneer investigator himself, and at the same time the leading historian in this field. The respect and regard in which McCollum is held throughout the world are indicated by the fact that he was among the

first to be accorded the honour of election as an honorary president of the International Union of Nutritional Sciences, and that he is also to be the honorary president of the Fifth International Congress of Nutrition to be held in Washington, D.C., in 1960.

In the judgment of the present writer, an essential part of the greatness of such men as McCollum and Drummond is that they have the ability to regard science as a matter of historical development and growth, rather than as a mere catalogue of facts or a repository for items of knowledge. It is a pity that this historical outlook is not more widely encouraged to-day in our colleges and universities. All too common is the student, superficially self-satisfied, who supposes that when the lecturer turns to discuss the historical evolution of his science, rather than to present him with ready-made summaries of current information, then is the time when he can relax or quietly fall asleep. Yet the fact is that no student can hope to acquire a proper understanding of the existing teaching in his chosen sphere except by learning how the current views have come to be accepted and what is the actual foundation for them. Indeed, to the young student aspiring to become a research worker, one might go further, and say that unless he is genuinely interested in studying the bases of knowledge—that is to say, following the reasons why certain beliefs, theories or scientific explanations are held, the stages through which accepted notions have gradually travelled, in other words, their historical background—he is not likely to have the mental approach that makes a successful investigator. We may extend the argument to the teacher himself. He is a less good teacher, and a less efficient teacher, who is content to leave his student with no more than the statement that such-and-such is now the established view, and that is all there is to it. He is the better teacher, and the more stimulating teacher, who gives his pupils an explanation of the following kind: formerly certain ideas were considered well founded; but later they had to be modified in some respects because of newer knowledge and fuller understanding; and that is the reason why the presently accepted belief is so-and-so; but that nevertheless various rival opinions are often justified on any topic; and that there are always bound to remain gaps in our knowledge and room for further developments and the possibility of wider interpretations.

No doubt it is this mental approach which has served to make Prof. McCollum not only a leader in nutritional thought but also a famous experimentalist, and the instigator of so much fine work by his 'school' of colleagues and pupils. One of his own most celebrated contributions dates back to 1913–15, when he gave the first demonstration of the probable multiplicity of "rat-growth factors", and by the designations "Fat-Soluble A" and "Water-Soluble B" set the stage for the system of classifying the vitamins now familiar to all. No less influential in provoking thought and moulding opinion was his celebrated book, "The Newer Knowledge of Nutrition", the first edition of which appeared in 1918, and which may be regarded as the earliest of the modern treatises on nutrition. In a sense, "A History of Nutrition" can be considered as an up-to-date revision of "The Newer Knowledge of Nutrition". In this new work, the reader will find an impressive survey of the whole field, and one that is at the same time scholarly, well balanced, illuminated by a sound, critical judgment and a wise discrimination. The treatment is sufficiently comprehensive, in the course of its 450 pages, to cover the ground adequately and without anywhere becoming laborious, wearying or unwieldy. Much of the text is the result of careful and loving original bibliographical research by the author himself. It is certain that any future writers on nutritional history will have to turn to McCollum's new book as their starting point.

As to the new edition of "The Englishman's Food", one need say no more than that on its first publication in 1939 it immediately became the standard work on the dietary conditions of, and the food habits of, ourselves and of our ancestors during the past five centuries. Nothing covering the same ground had been available previously, or has been published since; and this second edition was sadly overdue. Miss Dorothy Hollingsworth has done her work conscientiously and well in revising the book and bringing it up to date, and has added a useful new chapter on "The Application of the Newer Knowledge of Nutrition". Unhappily, because of the increasing costs of printing, the publishers found it necessary to reduce the overall size of the book, with the result that some of the earlier chapters have had to be shortened, chiefly by the omission of quotations from historical texts, some of them of fascinating interest. Many of us will regret this; but such is the sad lot of authors to-day.

LESLIE J. HARRIS

FLOW OF COMPRESSIBLE FLUIDS

Mathematical Theory of Compressible Fluid Flow

By Richard von Mises. Completed by Hilda Geiringer and G. S. S. Ludford. (Applied Mathematics and Mechanics: a Series of Monographs prepared under the auspices of the Applied Physics Laboratory, Johns Hopkins University.) Pp. xiii+514. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1958.) 15 dollars.

THIS book was originally planned by von Mises, but owing to his untimely death he was unable to complete his task. With the aid of some notes he left, Hilda Geiringer (Mrs. R. von Mises) and G. S. S. Ludford were, however, able to complete the work. The first three chapters were written by von Mises himself and the remaining two are due to the above-named authors, to whom everyone should be grateful for preserving so much of the last important work of von Mises.

The material contained in the book is intended for the research worker and the graduate student, but it should be of value to anyone making a serious study of aerodynamics. The basic theory is developed in a clear and simple way that is easy to understand. Great pains are taken to explain fully fundamental concepts and the significance of the various assumptions made in the development of the mathematical methods for the solution of certain aerodynamic problems. The concept of a specifying equation is introduced which, with the usual four equations of Euler connecting the velocity components of the flow, the pressure p and the density ρ, enables these five unknowns to be determined. The most common forms of the specifying equation are $\rho = \text{const.}$ for incompressible flow, and $F(p, \rho) = 0$ for compressible flow, where p and ρ are at all times connected by a one-to-one relation.

In scope the book is somewhat limited. Only one- and two-dimensional flows are fully discussed, and

in the main only problems of inviscid flow for which exact solutions have been found are considered. No attempts are made to assess the practical value of these theoretical results by comparison with experiment.

Chapter 1 gives the basic equations for different types of flow under various conditions and Chapter 2 is concerned with general theorems of use in the study of rotational flows, the hodograph method and the theory of characteristics. Chapter 3 is devoted to one-dimensional flow and contains sections on the effects of viscosity, heat conduction, simple wave propagation, shock reflexion and shock collision. A thorough presentation of the hodograph method, with a full discussion of recent advances in the theory, is included in Chapters 4 and 5. Special attention is given to the treatment of shock waves and the book ends with an article on transonic flow. The main text is followed by an appendix of some forty pages of relevant and most interesting biographical and historical notes.

W. P. Jones

THE METALLURGY OF MAGNESIUM

The Physical Metallurgy of Magnesium and Its Alloys

By Prof. G. V. Raynor. (International Series of Monographs on Metal Physics and Physical Metallurgy, Vol. 5.) Pp. ix+531. (London and New York: Pergamon Press, 1959.) 75*s*. net.

Prof. G. V. Raynor's latest book provides the first predominantly theoretical survey of the subject of magnesium and its alloys, and it will most certainly form a valuable companion volume to those books published in recent years concerned mainly with the technological aspects of magnesium metallurgy. Both students and those concerned with development in industry will welcome this authoritative work, which is presented so as to give the theory first, followed by a review with examples of the alloy systems formed by magnesium.

The first part of the book (Chapters 1–7) deals with the fundamental nature of magnesium, its electronic constitution, and the effects of alloying. This section contains a masterly ten-page summary of the electron theory in general, before presenting a critical account of the qualitative and quantitative studies that have been made of the electronic constitution of magnesium. Magnesium is in a most interesting electronic state, and the author discusses, in a chapter on the lattice spacings of magnesium alloys, electronic interpretations of departures from Vegard's law, and lattice spacing changes due to temperature changes and to the application of tensile stress.

After a description of the general alloying behaviour of magnesium, in terms of the Hume-Rothery factors of atomic size, and relative- and electro-negative valency effects, an extensive account is given of the occurrence of intermediate phases in magnesium alloys. In particular, the structures of 'normal valency' compounds and Laves phases are considered in some detail, and the chapter is concluded by some pertinent observations as to why precipitation of these intermediate phases seldom leads to a high response to age-hardening in magnesium alloys.

This section of the book is concluded by an account of the deformational characteristics of single crystals and polycrystalline aggregates. After a fairly elementary description of edge and screw dislocations, the crystallography of slip and twinning in magnesium at room and elevated temperatures is outlined. Rupture, and the development of preferred orientations, are also considered, and an account of creep characteristics concludes the chapter.

The second part of the book (Chapters 8–17) describes and discusses the alloys of magnesium, considering the solute metals from the various groups of the Periodic Table in turn, stress being laid on those of present or potential importance. A selected list of references is provided at the end of each chapter—the literature being reviewed up to and including 1957. Rapid reference to this part of the book would be made easier by the more generous provision of sub-headings, as the alloys in each group are discussed.

A review of this nature emphasizes our ignorance of the fundamental mechanism of many technological processes, and many fields for further research are indicated. The suggestion of "submicroscopic precipitates" in, for example, the creep-resistant magnesium–cerium alloys will certainly whet the appetite of electron microscopists. There is, in fact, rather a dearth of photomicrographs in the book (there being only two sets), doubtless due to the high cost of their production. The value of the second set of micrographs is also reduced by the absence of any supplementary information—magnification, preparation, etc.

An account of the systems formed with gaseous elements or compounds concludes the review, an interesting discussion of the oxidation characteristics of the metal being included here. The final chapter summarizes the influence of alloying on the mechanical properties of magnesium. The book contains more than 200 diagrams—the phase diagrams being particularly well produced. This robust, well-bound volume will surely grace the shelves of students and research workers alike for many years to come.

J. W. Martin

BIOLOGICAL PROPERTIES OF PHENOLS OF PLANT ORIGIN

The Pharmacology of Plant Phenolics

Proceedings of a Symposium held at Oxford, April 1958. Edited by J. W. Fairbairn. Pp. ix+151. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1959.) 6 dollars; 30*s*.

It is not often that an attempt is made to present within the space of 150 pages a review of the biological properties of such a wide variety of chemical substances as the plant phenolics. It can indeed be argued that such a review can be of little value because the plant phenolics comprise a miscellaneous assortment of substances having nothing in common beyond the presence of an aromatic hydroxyl group, and some may feel that the choice of subject-matter has been made even more arbitrary by the inclusion of the chapter on adrenaline, noradrenaline and 5-hydroxytryptamine, since these substances are not of plant origin and owe their characteristic pharmacological properties to the presence of an amino-group rather than to the presence of a phenolic group.

Even if the fundamental pattern of this book—the proceedings of a symposium held in Oxford last year—is regarded as slightly illogical, it represents

nevertheless, an important contribution to the field of structure–activity relationships.

The book begins with a concise authoritative chapter by J. H. Burn on adrenaline and other nitrogen-containing phenols mainly of animal origin, and is followed by another chapter, by R. T. Williams, summarizing what is known concerning the fate of phenolic compounds in the body. In the third chapter W. B. Whalley discusses the toxicity of plant phenolics as a group, providing a useful introduction to the next five chapters which describe in more detail the action of specific groups of compounds. J. W. Fairbairn, who is also the general editor, discusses the anthraquinones, and J. D. Biggers geneistein and related compounds which exhibit œstrogenic activity and, in a separate chapter, hypericin and similar compounds that cause photo-sensitization. Three chapters are devoted to the flavonoids and their effect on capillary blood flow. In the first M. F. Lockett considers the evidence in support of the view that they act directly on capillary permeability and tensile strength, while in the other two F. Deeds and J. Lavollay and J. Neumann present the case for indirect activity, mediated through adrenaline and ascorbic acid. The last two chapters of the book deal with plant phenolics in food and wine, J. Masquelier directing attention to the high bactericidal activity of some wines and E. C. Bate-Smith concluding the book on the reassuring note that most of the phenolic constituents of foods are fortunately pharmacologically inert.

The book is well printed and free from errors. Its value is greatly enhanced by the list of references given at the end of each chapter and by summaries of the discussions that took place at the symposium. Most pharmacologists, organic chemists, biochemists and pharmacists will find much of interest and value in this volume.

F. A. Robinson

ORCHARD SCIENCE

Tree Fruit Production

By James S. Shoemaker and Benjamin J. E. Teskey. Pp. vii+456. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959.) 56*s*. net.

ADVANCES in plant physiology, in plant breeding, in plant protection and in the knowledge of plant toxicants, are to-day being paralleled by advances in crop husbandry and soil management, and in tree shaping and growth control. The impact of these advances on commercial fruit-growing is being influenced by economic considerations. While the facets are the major concern of the appropriate specialist, who may be quite ignorant of the over-all subject of pomology, the teacher of pomology, as the term is now generally understood, must be keenly aware of the progress being made in all the branches of fundamental science that affect his subject and be willing and able to incorporate the new knowledge in turn into his teaching and demonstrations.

With specialist fruit-crop research stations in many parts of the world now more or less well staffed and equipped, new knowledge, supposedly new knowledge or old knowledge recapitulated is being published so plentifully as to embarrass alike both teacher and taught. From time to time experienced teachers give us the benefit of their selection from among this wealth of material and, if they are competent teachers and are critical in their selection, the result is a good book.

Dr. Shoemaker is such a teacher, and this book, written in collaboration with Dr. Teskey, bears evidence of a wide-ranging but careful selection of subjects (there are more than 800 references, the majority of them within the past 20 years) and a commendable compression of the essential material; an 11-page double-columned index makes for easy reference. Text-books on husbandry are difficult to illustrate, and this one is no exception; line drawings and diagrams, like those on grafting, are clear and good; photographs of plantations and many field operations, like picking and pruning, do not reproduce well.

The authors have covered apples, pears, cherries and plums, all of which interest us in the British Isles. Peaches, apricots, nectarines and quinces should interest our Western and Southern European neighbours, and citrus fruits are also the concern of the countries bordering the Mediterranean sea. The authors were not catering for this wide public but aimed at producing an up-to-date guide to current orchard and fruit plantation practice for use in Canada and America. Nursery practice, site selection and modification, planting considerations and varieties for particular purposes are all discussed, together with tree nutrition, pest and disease control, soil and plantation management and harvesting as well as handling and storage. There is a special chapter on the cultivation of dwarf apples and pears, evidently in response to demands from students for information on this subject. For a long time European growers have been particularly expert in controlling tree size and yield, and American growers may face many difficulties in adapting European methods to their needs.

Though essentially written for students this book contains much that will interest fruit growers and their advisors in many parts of the world.

H. W. Miles

SCHIZOPHRENIA

Schizophrenia: Somatic Aspects

Edited by Derek Richter. Pp. viii+181. (London and New York: Pergamon Press, 1957.) 40*s*. net.

Chronic Schizophrenia

By Thomas Freeman, John L. Cameron and Andrew McGhie. Pp. xi+158. (London: Tavistock Publications, Ltd., 1958.) 21*s*. net.

A New Approach to Schizophrenia

By Julius I. Steinfeld. Pp. 159. (London: Hutchinson Medical Publications, Ltd., 1958.) 21*s*. net.

SCHIZOPHRENIA is a major cause of disability in most parts of the world. In countries for which statistics are available it constitutes approximately half the chronic population of mental hospitals. Almost one in every hundred persons is fated to suffer from the disease, and the majority, particularly the men, break down in the second and third decades of life. The wastage of human life and the amount of suffering and social dislocation it causes are probably greater than that due to any other single disease. The International Congress of Psychiatry held two years ago was devoted wholly to this subject. Its deliberations served largely to bring home the failure to

achieve any substantial advance in knowledge of its causation since the condition was first described by Kraepelin and later further defined by Bleuler.

These three books reflect three of the commoner types of theoretical approach adopted in the vast literature on the subject: the organic or somatic approach, the psycho-analytic and the eccentric.

The monograph edited by Derek Richter contains a number of essays dealing with the present state of knowledge in relation to the anthropometric aspects and the electroencephalographic, neuropathological and endocrinological observations. There is a study of metabolic changes in recurrent schizophrenia, one on the effects of drugs introduced into the cerebral ventricles, a paper on the therapeutic effects of drugs and on the symptoms induced by mescaline which are at times scarcely distinguishable from those observed in schizophrenics. One paper attempts to reconcile the observations suggesting that a mutant gene is the primary cause with those that imply that environmental causes are of some importance. The picture of present knowledge that emerges is scarcely encouraging. Schizophrenics differ as a group from normal controls in respect of body build and in relation to a whole range of biochemical tests. There is some evidence that histologically demonstrable changes occur in some parts of the brain. The schizophrenic also responds abnormally to a wide range of drugs. But all these changes are without specificity and the degree of overlap with normal control groups is so great for all anomalies that they are rendered useless for purposes of diagnosis. In many instances uncertainty remains as to whether we deal with manifestations of causal agents, with effects of the disease or the results of long periods of institutional care. Moreover, with the possible exception of Gjessing's celebrated work on disturbances of nitrogen metabolism in the very small group of cases of periodic catatonia, none of the differences found has been so far successfully exploited to advance knowledge in relation to ætiology, prognosis or classification. The one hard fact which shines clear and constant through this nebulous matrix of data is that the hazard for developing schizophrenia in the sib of a schizophrenic is some ten times that for a member of the general population; for his child sixteen times, for a dizygotic twin some thirteen times and for a monozygotic twin between seventy and eighty times as great. Although its significance remains unclear, the recently demonstrated difference in the chance of being admitted to mental hospital with schizophrenia in the different social classes has been already confirmed in a number of countries and promises to be an equally clear and consistent observation.

The dismally slow rate of progress along organic lines has led some workers to throw up the sponge and to devote their energies to the uncovering of meaningful associations in the mental life of the schizophrenic. The theoretical framework for this kind of endeavour is usually provided by one of the schools of psycho-analysis. The stringent controls considered essential for scientific inquiry to ensure that findings are not interpreted in accordance with preconceived theory are often regarded as inapplicable or irrelevant. The psychoanalytic exploration and treatment of schizophrenia has in recent years attracted enthusiastic adherents; it had previously been considered therapeutically useless.

The book by Dr. Freeman and his colleagues deals with observations and treatment inspired by psychoanalytic teaching and carried out in two groups of chronic schizophrenic patients. They concur in the view expressed by Federn that the essential psychological disturbance produced by this disorder is a weakening of the functions of the ego leading to a breakdown of its boundaries and failure to differentiate between self and non-self or environment. Variations in the form of the disease are attributed to the degree of ego function. The disorders of thought, affect and volition and the disturbances of perception characteristic of the schizophrenic are all considered to stem from the change in the experience of the self. Although this is regarded as the essential psychological disturbance, the problem of ætiology is left open. The therapeutic programme based on these findings is directed towards ego-building, which includes fostering closer and more durable relationships between patients and nurses, efforts to communicate at the patient's own archaic level, and, on the assumption that stimulation of the body enhances awareness of the self, such things as stroking the face and making a ceremonial of bath-time. The effects of these measures on ward atmosphere and on individual patients are said to have been gratifying but no clear analysis of the results is given.

Exploration of the inner life of the schizophrenic is of value as a form of inquiry, and a premature insistence on quantitative data in a field such as this can prove stultifying to new ideas. Some Continental psychiatrists who do not subscribe to psychoanalytic teaching have testified to the beneficial effect exerted by this kind of endeavour when initiated in a mental hospital where formerly the predominant influence was the so-called "objective" psychiatry, the adherents of which at times unwittingly treated the patient almost as if he had been an inanimate object.

However, the scientific merit of theories cannot be decided by pragmatic considerations. The breakdown of ego boundaries here described as the source of all psychological disturbances in schizophrenia is equally applicable as a metaphorical description for the mental disturbances in delirium, dementia, dreaming and depersonalization, which are quite different phenomena. Moreover, a very large number of unifying explanations have now been proposed, all claiming to be illuminating for the understanding and efficacious in the treatment of schizophrenia. Thus Dr. Steinfeld's book states that oral frustration in infancy is the root cause. Excessive hunger in early life over-strains the vegetative mechanisms, which may then remain in a state of high catheris through life. He has more than a suspicion, for reasons not made explicit, that in carcinomatosis similar mechanisms may be at work.

As in other fields of scientific inquiry, insights, and 'intuitive leaps' in psychiatry have to be treated with respect—those of others no less than one's own—which is precisely why none deserves serious consideration until its relevance and heuristic value have been objectively demonstrated so far as possible.

Many observations cited in the first book suggest that the slow progress of scientific inquiry in this field may be partly due to the heterogeneity of schizophrenia. Recent genetic, clinical and epidemiological data show promise for discovery of the natural lines of division between the different variants in the syndrome. When this has been achieved, progress in the definition of causal agents in schizophrenia, whether psychogenic or physiogenic, is likely to be accelerated.

Martin Roth

The World of Learning 1958–59

Ninth edition. Pp. xiii+1139. (London: Europa Publications, Ltd., 1958.) 130*s*. net.

THE ninth edition of the "World of Learning", which is now well established as a valuable guide to scientific, cultural and educational institutions throughout the world, follows the pattern of its predecessors, but is considerably enlarged, due to the world-wide expansion of scientific and technological research, and to the recent foundation of many universities and technical colleges in the relatively undeveloped countries.

The first section, devoted to Unesco, describing its aims, programmes, organization and finance, is followed by a short account of the work and structure of the International Council of Scientific Unions and other international organizations, together with brief statements of their objects and the names of their principal officers.

The remainder of the book is divided alphabetically into the various countries of the world (by their names in English). The arrangement of entries for Great Britain—which occupy 86 pages—affords an indication of the scope of the work: learned societies and professional associations; research institutes; libraries; museums and art galleries; universities and university colleges; centres of adult and technical education; schools of art, music and dramatic art; agricultural colleges; and education trusts. In general, the entry for each institution includes its address, the names of its leading officials; and for each university a complete list of professors is given. Where applicable, the titles of any publications issued by the body concerned are also listed. The entry for the U.S.S.R., which occupies 38 pages, lists the members of the Soviet Academy of Sciences and the heads of its various departments and research organizations. Forty-one Russian universities are listed, with their faculties, but the names of their professorial staffs are not given; a long list of the very numerous institutions of higher education and research of the Soviet Union are, however, included. The largest single entry, comprising 190 pages, relates to the United States of America.

There is an alphabetical index of institutions, but none of persons, mentioned in the book.

Handbook of the Rubi of Great Britain and Ireland

By the late W. C. R. Watson. Pp. xi+274 (50 figures). (Cambridge: At the University Press, 1958.) 63*s*. net.

PROFESSIONAL systematists tend to be superior about brambles and batologists, partly because, in Britain at least, batology has been primarily an amateur study, but perhaps more particularly because the *Rubi* refuse to comply with orthodox ideas, and, like slum children in a respectable neighbourhood, are a perpetual affront to the dignity of those who value orderliness and correct behaviour. It was perhaps vain to hope that Mr. Watson's long-awaited monograph would finally set the seal of respectability upon this sprawling and troublesome group, but the opinions of one who studied the brambles assiduously for more than forty years must be given careful consideration. Every line of this admirably produced monograph bespeaks seriousness of purpose, integrity and industry, and the wealth of Watson's knowledge is testified time and time again throughout the book, though perhaps most strikingly in the introductory pages. What a pity the author did not live to publish a separate and more elaborate essay on brambles and bramble classification, for it must be confessed that his generalizations and *obiter dicta*, though perhaps controvertible, are vastly more intriguing than his detailed and somewhat desiccating descriptions of the three hundred and ninety-one species said to occur in Britain. Admittedly everything possible has been done, in keys, descriptions and illustrations, to convey the author's mature conclusions to the reader, but language and art have their limitations, and the fond hope that the book will "furnish the means of identifying every native species met with" is perhaps a shade too optimistic. The unenlightened sees only one blackberry; the observant possibly half a dozen, but only the specialist, with twenty or more years experience behind him, can hope to recognize the majority of the species included in this book; and then—who knows—the specialist may wish to add a further hundred species of his own to the British list, for one suspects that *Rubus* species, like parallel lines, can be extended to infinity. R. D. MEIKLE

Annual Review of Entomology

Vol. 4. Edited by Edward A. Steinhaus in association with Ray F. Smith. Pp. viii+467. (Palo Alto, Calif.: Annual Reviews, Inc., 1959. Published in co-operation with the Entomological Society of America.) 7 dollars.

A REVIEWER always likes to imagine editors and authors feverishly scanning his Olympian judgements and then departing to brood on the error of their ways. While experience must inevitably destroy this pleasant picture, it is gratifying to notice the present coincidence: Volume 4 of the "Annual Review of Entomology" fulfils almost entirely the critical requirements suggested in reviews of the previous volumes in these columns. Thus we have a volume broadly based not only in subject-matter but also in the geographical distribution of its contributors; a review which includes several papers on subjects at the 'growing-points' of entomology—insect physiology, ecology and control—and finds space for one or two on the borderline of other sciences, such as the role of insects as disease vectors. In fact, it would be a dull entomologist indeed who could not find something of interest or profit in the present volume.

If this standard is maintained then critical interest can be transferred to a higher level; although in the present volume the general concept is good, a few of the individual treatments fall short of this standard and degenerate into the 'card-index' type of review. Review articles of the highest quality must not only present a selection—for in these days that is all it can be—of the literature but must also strive to produce some stimulating and if possible enlightening synthesis from it.

In matters of detail the present volume is as well produced as its predecessors and at last each article has a bibliography in alphabetical order; the index is good, although several misprints and incorrect page numbers appear here.

But these are small matters compared with the solid value and interest of this volume; the Entomological Society of America, which this year terminates its financial obligations to the "Review", must be congratulated on bringing into being a work which, on present standards, will be of great value to every entomologist. P. T. HASKELL

RADIOCARBON DATING OF PREHISTORIC WOODEN TRACKWAYS

By Dr. H. GODWIN, F.R.S., and Dr. E. H. WILLIS
University Sub-department of Quaternary Research, Botany School, Cambridge

THE purpose of building corduroy tracks is to avoid detours, and prehistoric examples of these wooden structures have been preserved by continuous water-logging. It is not surprising, therefore, that increased wetness of climate should have caused many former routes to be flooded, and have induced first the construction and then the preservation of wooden trackways. Thus there is an expectation that, were it possible to determine the age of a number of trackways, their ages would be grouped at distinct periods of climatic deterioration.

Corduroy tracks, however, have not been studied typologically, and apart from axe-marks on the timber and the chance of associated archæological finds, they have been very difficult to date, until the advent of pollen-analysis, and, more recently, of radiocarbon dating.

Both techniques have been applied to the problem of dating several of the wooden trackways revealed in recent years by peat-cutting in the derelict raised bogs of the Somerset Levels. Some of these have been described already[1], and descriptions of others are being prepared for publication (*Phil. Trans. Roy. Soc. Edinburgh*). They run between the Mendip and the Polden Hills and the low islands that project through the intervening flat lowlands of the Glastonbury Levels.

The six Somerset trackways so far dated, and also certain associated wooden platforms, all occur at a comparable stratigraphic horizon in the bogs. This is at the surface of a very dark, highly humified *Sphagnum–Calluna–Eriophorum* peat, and its junction with a *Cladium–Hypnum* peat. The lower peat is indicative of the growth of heather-clad bogs receiving water only as rain or snow, in a condition of arrest or slow growth: their gentle convex surfaces could easily have been traversed on foot and offered little obstacle to passage across the levels. The overlying *Cladium–Hypnum* peat by contrast points unmistakably to flooding by calcareous water from the big catchment area of the Mendips and Polden Hills. Such flooding imposed very circuitous routes between one hill ridge and another and the evidence suggests that the wooden trackways were built in consequence of the flooding and that their preservation was ensured by its continuance.

Several of the trackways were also shown to be close to the same pollen-analytic zone-boundary, and upon this evidence it was suggested that the tracks were probably built about the transition between the Bronze Age and the Iron Age. This supposition was strengthened by the occasional discovery upon the timber of the markings of the small thick axes of Late Bronze Age type, and by the recovery of two bronze spearheads at comparable stratigraphic levels, one of the Late Bronze Age and the other of late Middle Bronze Age.

Radiocarbon dates have now been obtained for the wood of the trackways and also of the peat in which they are embedded. The assays were made with carbon dioxide at 2 atmospheres pressure in a copper proportional counter of about 2-litres volume[2].

Table 1. Dating of Wood from Trackways*

		Years B.P.
Q 52	Meare Heath track (Bulleid's)	2840 ± 110 2850 ± 110
Q 39	Shapwick Heath track (Foster's)	2470 ± 110
Q 308	Westhay track (Sandford's)	2800 ± 110
Q 306	Blakeway Farm track	2600 ± 110
Q 7	Vipers track (Dewar's A)	2520 ± 110
Q 312	Vipers track (Dewar's A)	2630 ± 110
Q 313	Nidons track (Dewar's B)	2585 ± 120
Q 311	Vipers platform	2410 ± 100 2640 ± 110

* For fuller information on the provenance of the samples see ref. 3.

It will be seen that these all lie between 450 and 900 B.C., which is certainly Late Bronze Age in this part of Britain. The datings are supported by those of the associated peat.

Table 2. Dating of Peat associated with Trackways

		Years B.P.
Q 53	Meare Heath track—subjacent peat	3230 ± 110
Q 44	Shapwick Heath track—subjacent peat	3310 ± 110
Q 309	Blakeway Farm track—subjacent peat	2790 ± 110
Q 316	Nidons track—peat at track level	2590 ± 120
Q 318	Nidons track—subjacent peat	2642 ± 120
Q 319	Nidons track—subjacent peat	2482 ± 120
Q 317	Nidons track—superjacent peat	2628 ± 120

Whereas the results from Nidons track suggest close contemporaneity between the track itself and adjacent peat, at the other sites the greater age of the underlying peat supports the field evidence that some erosion or wastage of the peat surface had occurred before the trackways were constructed.

As long ago as 1906 a monoxylous boat had been recovered from the bog deposits near Shapwick Station, but under conditions that did not allow any dating or reference to a stratigraphic horizon. It was apparent that it could not have been embedded while the bogs were covered by heather and cotton-grass and it seemed likely that it related to a substantial flooding period. The curator of Taunton Castle Museum, where the boat is now preserved, kindly provided enough wood for the following radiocarbon assay:

Q 357 Shapwick boat 2305 ± 120 years B.P.

It will be seen that this assay places the boat within the Early Iron Age, so that it is younger than the wooden trackways and indeed corresponds in age with the *Cladium–Hypnum* peat of the major flooding episode of this time.

There is a good deal of evidence in various parts of north-western Europe that about 600 B.C. there was in progress a change of climate towards increased rainfall and lower temperatures. It has been made the boundary between the Sub-boreal and Sub-atlantic climatic periods; it is an important pollen-zone boundary and is often marked by 'recurrence-surfaces' in peat bogs. In view of the likelihood that this climatic change was also widespread in Britain it is interesting to append the radiocarbon dates

from three further wooden trackways that we determined.

Table 3. TRACKWAYS OUTSIDE SOMERSET

		Years B.P.
Q 310	Fordy—Little Thetford, Cambs.	2560 ± 110
Q 77	Brigg, Lincs.[5]	2552 ± 120
Q 68	Kate's Pad, Pilling, Lancs.	2760 ± 120

It was already known from associated prehistoric finds that the Brigg trackway clearly belonged to the Late Bronze Age to Early Iron Age transition. Pollen-analytic evidence and a single sherd from the Fordy trackway had already suggested a similar age for that structure. It is now strikingly evident that indeed all the trackways belong to the one archæological period.

Of course, prehistoric trackways were built at other periods than this, and the Groningen laboratory has dated an Irish example as follows:

GRO 272 Corlona, Co. Leitrim 3395 ± 170 years B.P.

None the less, the consistency of the English results is striking and strongly underlines the importance of carefully recording and dating these unregarded prehistoric monuments.

[1] Clapham, A. R., and Godwin, H., *Phil. Trans. Roy. Soc.*, B, **233**, 233 (1948).
[2] Godwin, H., Walker, D., and Willis, E. H., *Proc. Roy. Soc.*, B, **147**, 352 (1957).
[3] Godwin, H., and Willis, E. H., *Amer. J. Sci.*, Radiocarbon Supp., **1**, 63 (1959).
[4] Mitchell, G. F., *J. Roy. Soc. Antiq. Ireland*, **88**, 49 (1958).
[5] Smith, A. G., *Proc. Prehist. Soc.*, **24**, 78 (1958).

A NEW FOSSIL SKULL FROM OLDUVAI

By DR. L. S. B. LEAKEY
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ON July 17, at Olduvai Gorge in Tanganyika Territory, at Site *FLK*, my wife found a fossil hominid skull, at a depth of approximately 22 ft. below the upper limit of Bed I. The skull was in the process of being eroded out on the slopes, and it was only because this erosion had already exposed part of the specimen that the discovery was possible. Excavations were begun on the site the following day and continued until August 6. As a result, an almost complete skull of a hominid was discovered. This skull was found to be associated with a well-defined living floor of the Oldowan, pre-Chelles-Acheul, culture.

Upon the living floor, in addition to Oldowan tools and waste flakes, there were the fossilized broken and splintered bones of the animals that formed part of the diet of the makers of this most primitive stone-age culture. It has not yet been possible to study the fauna found on this living floor; but it can be said that it includes birds, amphibians, reptiles such as snakes and lizards, many rodents and also immature examples of two genera of extinct pigs, as well as antelope bones, jaws and teeth.

It is of special importance to note that whereas the bones of the larger animals have all been broken and scattered, the hominid skull was found as a single unit within the space of approximately one square foot by about six inches deep. Even fragile bones like the nasals are preserved. The expansion and contraction of the bentonitic clay, upon which the skull rested and in which it was partly embedded, had resulted, over the years, in its breaking up into small fragments which have had to be pieced together. The bones, however, are not in any way warped or distorted. A large number of fragments still remain to be pieced together.

This very great difference between the condition of the hominid skull and that of the animal bones on the same living floor (all of which had been deliberately broken up) seems to indicate clearly that this skull represents one of the hominids who occupied the living site; who made and used the tools and who ate the animals. There is no reason whatever, in this case, to believe that the skull represents the victim of a cannibalistic feast by some hypothetical more advanced type of man. Had we found only fragments of skull, or fragments of jaw, we should not have taken such a positive view of this.

It therefore seems that we have, in this skull, an actual representative of the type of 'man' who made the Oldowan pre-Chelles-Acheul culture.

This skull has a great many resemblances to the known members of the sub-family of Australopithecinae. Some scientists recognize only one genus, namely, *Australopithecus*, and treat Broom's *Paranthropus* as a synonym; others consider that the demonstrable differences are of such a nature that both genera are valid. Personally, having recently re-examined all the material of the two genera, in Johannesburg and Pretoria, I accept both as valid.

The Olduvai skull is patently a member of the sub-family Australopithecinae, and in certain respects it recalls the genus *Paranthropus*. In particular, this is the case in respect of the presence of the sagittal crest, the great reduction in the size of the canines and the incisors, the relatively straight line of these teeth at the front of the palate, the position of the nasal spines and the flatness of the forehead. In certain other characters, the new skull resembles more closely the genus *Australopithecus*, for example in respect of the high cranial vault, the deeper palate and the reduction of the upper third molars to a size smaller than the second, all of which are features to be found in *Australopithecus* but not in *Paranthropus*.

The very close examination and direct comparisons which I have personally made in South Africa have convinced me that, on the basis of our present state of knowledge, the new skull from Olduvai, while clearly a member of the Australopithecinae, differs from both *Australopithecus* and *Paranthropus* much more than these two genera differ from each other.

I am not in favour of creating too many new generic names among the Hominidae; but I believe that it is desirable to place the new find in a separate and distinct genus. I therefore propose to name the new skull *Zinjanthropus boisei*. This generic name derives from the word 'Zinj', which is the ancient name for East Africa as a whole, while the specific name is in honour of Mr. Charles Boise, whose constant encouragement and financial help ever since 1948 have made this and other important discoveries possible. I would also like to acknowledge the generous help received, from time to time, from the Wenner-Gren Foundation and the Wilkie Trust.

The following is the preliminary diagnosis of the new genus and the new species :

Zinjanthropus gen. nov. :

Genotype : a young male with third molars not yet in wear and sutures relatively open, from *FLK* I, Olduvai.

A new genus of the Hominidae, sub-family Australopithecinae, which exhibits the following major differences from the genera *Australopithecus* and *Paranthropus* :

(*a*) in males a nuchal crest is developed as a continuous ridge across the occipital bone ;

(*b*) the inion, despite the great evidence of muscularity, is set lower (when the skull is in the Frankfurt plane) than in the other two genera ;

(*c*) the posterior wall of the occipital bone rises more steeply to form, with the parietals, a very high-vaulted posterior region of the skull ;

(*d*) the foramen magnum is less elongate and has a more horizontal position than in *Australopithecus* (in the crushed skulls of *Paranthropus* it is not possible to be quite sure of the plane of the foramen magnum) ;

(*e*) the presence of a very massive horizontal ridge or torus above the mastoids. This is much more marked than the normal type of supra-mastoid crest ;

(*f*) the mastoids are more similar to those seen in present-day man, both in size and shape ;

(*g*) the presence of a strong wide shelf above the external auditory meatus, posterior to the jugal element of the temporal bone ;

(*h*) the shape and form of the tympanic plate, whether seen in *norma lateralis* or in *norma basalis*. In this character the new skull has similarities with the Far Eastern genus *Pithecanthropus* ;

(*i*) the very great pneumatosis of the whole of the mastoid region of the temporal bones, which even invades the squamosal elements ;

(*j*) the massiveness of the jugal element of the temporal bone relative to the total size of the temporal bone ;

(*k*) the way in which the parietals rise almost vertically behind the squamous elements of the temporal before bending over to become a dome ;

(*l*) the relative thinness of the parietals in comparison with the occipitals and the temporals ;

(*m*) the very prominent and keeled anterior margin of the crests on the frontal bone for the anterior segment of the temporal muscles in the region of the post-orbital constriction (even the most

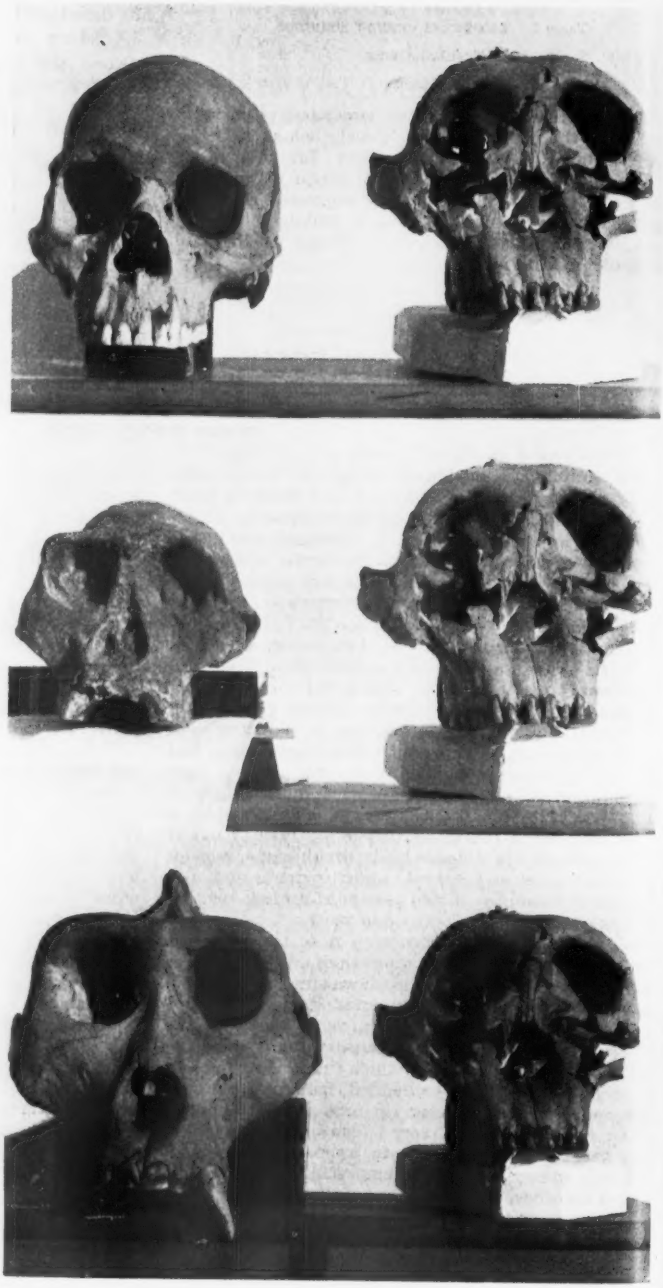

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Fig. 1. *Above* : The new skull compared with the skull of an Australian aboriginal. Note the very long face, the architecture of the malar region, the unusual nasal bones, the torus above the mastoid, the sagittal and nuchal crests. *Middle* : The new skull compared with a cast of the most complete adult of *Australopithecus*. Note the difference in the size and shape of the face, the shape of the tympanic plate, the low position of the inion, the huge mastoid, as well as the difference in the shape of the malar region and the supra-orbital area. *Below* : The new skull seen next to that of a gorilla

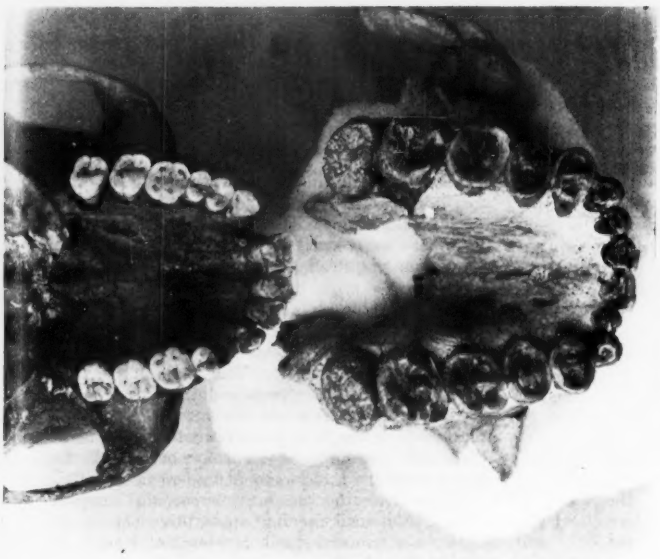

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Fig. 2. The palate of the new skull compared with that of an East African native

muscular male *Paranthropus* exhibits nothing comparable) ;

(*n*) the very unusual position of the nasion, which is on the most anterior part of the skull, instead of being behind and below the glabella region ;

(*p*) the very great absolute and also relative width of the inter-orbital area, with which may be associated the shape of the nasal bones, which are much wider at the top than at their inferior margin ;

(*q*) the whole shape and position of the external orbital angle elements of the frontal bone ;

(*r*) the very deep palate which is even more markedly like that of *Homo* than in *Australopithecus*, and is quite unlike the form seen in *Paranthropus*, except in respect of the more or less straight canine-incisor line which has already been commented on, as a character recalling *Paranthropus* ;

(*s*) the conformation of the malar-maxillary area of the cheek. In all known members of the genera *Australopithecus* and *Paranthropus* there is a buttress of bone which runs down from the malar towards the alveolar margin of the maxilla in about the region of the fourth premolar ; in *Zinjanthropus* this buttress is wholly absent and the form of architecture of this region is that which is found in *Homo* ;

(*t*) the very great area of muscle attachment on the inferior margin of the malars ;

(*u*) the relatively greater reduction of the canines in comparison with the molar–premolar series than is seen even in *Paranthropus* ; where it is a marked character.

Zinjanthropus boisei sp. nov.

A species of *Zinjanthropus* in which the males are far more massive than the most massive male *Paranthropus*. The face is also excessively long. Males have a sagittal crest, at least posteriorly. Upper third molars smaller than the second.

The above is only a preliminary diagnosis of the genus *Zinjanthropus* species *boisei*. It is recognized that, if and when further material is found, the diagnosis will need both enlarging and possibly modifying.

The whole question of generic value is one which is relative. There are some who maintain that *Australopithecus* and *Paranthropus* are not generically distinct, and who will wish to treat *Zinjanthropus* as a third, but less specialized, species of a single genus ; but the differences seem to be too great for this.

I must now turn to the absolute and relative geological age of the new skull. As stated earlier, *Zinjanthropus* comes from Olduvai Gorge, about 22 ft. below the upper limit of Bed I. It was found in association with tools of the Oldowan culture, on a living floor and with associated fauna.

In the past it has been customary to regard Olduvai Bed I as a part of the Middle Pleistocene, not differentiating it from Bed II. During the last few years, however, detailed excavations at sites *BK* II, *SHK* II and *HWK* II have shown that there is a constant and well-marked break between the top of Bed I and the base of Bed II. It is incidentally on this clearly defined land surface that Chellean Stage I living sites are found.

There has also been found a great deal of new faunal evidence, and it is now clear that the fauna of Olduvai Bed I is the same as that of Omo, and that both are generally of the same age as that of Taungs. In other words, it is now necessary to regard Olduvai Bed I as representing the upper half of the Villafranchian and not the lower part of the Middle Pleistocene. So far as relative dating is concerned, it now seems clear that in the Far East the Djetis beds belong to the Middle, rather than to the Lower, Pleistocene, so that the new Olduvai skull would be older than the oldest *Pithecanthropus*.

In South Africa, the deposits at Taungs and Sterkfontein are now regarded as belonging to the upper part of the Lower Pleistocene ; they must therefore be regarded as generally contemporary with Olduvai Bed I. The Makapan beds are a little younger, in all probability, while Swartkrans is of Middle Pleistocene age, as are the upper beds at Sterkfontein which are now yielding stone tools.

With the Taungs child, therefore, and the *Australopithecus* fossils from the lower beds at Sterkfontein, the new find represents one of the earliest Hominidae, with the Olduvai skull as the oldest yet discovered maker of stone tools.

The following approximate measurements will indicate the size of the new specimen.

Length from inion to glabella	about 174 mm.
Greatest breadth at supra-mastoid torus	,, 138 mm.
Greatest breadth of brain case on squamosal element of the temporal bones	,, 118 mm.
Height (in Frankfurt plane) from basion to a point vertically above it in the sagittal plane	,, 98 mm.
External orbital angle width	,, 122 mm.
Inter-orbital width	,, 32·5 mm.
Post-orbital width	,, 88 mm.
Palate-length from front of incisors to a line joining back of third molars	,, 84 mm.
Palate-width at second molars	,, 82 mm.
Palate-width at third premolars	,, 62 mm.
Length of molar–premolar series	,, 72 mm.

Teeth measurements :

*M*3 : 21 × 16 mm. ; *M*2 : 21 × 17 mm. ; *M*1 : 18 × 15·5 mm. ; *PM*4 : 18 × 12 mm. ; *PM*3 : 17 × 11·5 mm. ; *C*1 : 9·5 × 9 mm. ; *C*2 : 7 × 7 mm. ; *C*1 (both damaged but about 10 × 8 mm.).

ASPIRIN AND ALGESIMETRY

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ASPIRIN relieves mild natural pain of various causes and locations. It is reasonable to expect, therefore, that it should raise the minimal noxious stimulus required for an experimental nociceptive response in animals or for experimental pain perception in man. This has been realized in several laboratories with satisfactory validity; but experiments have failed. Success and failure by respective procedures exist side-by-side in the same laboratory without explanation. We, like others, have repeatedly failed to demonstrate an effect of intraperitoneally administered aspirin on the threshold amount of mechanical pressure on a rat's tail required to induce squeaking[1]. We have succeeded, on the other hand, in showing an effect by the same route on the threshold intensity of radiant heat, applied to the back of guinea pigs, that is required to elicit a twitch of the skin muscles[2]. The success is often repeated[3]; and the dose of aspirin required is in appropriate relationship to doses of morphine or meperidine required in the same procedure—all high, relative to human doses.

Magnitude of Experimental Anti-nociceptive Effect

The greatest rise in nociceptive threshold caused by increasing intraperitoneal doses of aspirin in the guinea pigs is about 30 per cent[2,3]. Similarity of this magnitude to that originally reported by Wolff *et al.*[4] for the rise in radiant thermal threshold for pain perception in man is only coincidental. When the guinea pigs were given aspirin by stomach tube instead of intraperitoneally, even large, toxic doses caused no more than 10–15 per cent rise in threshold[5]. When Wolff's group adopted a less biasing experimental design with placebo control, a change bearing no relationship to the change in route of administration in guinea pigs, the ceiling of effect in man also became 10–15 per cent[6]. The factors responsible for the larger intraperitoneal effect in guinea pigs remain unknown.

A similar small effect of aspirin was observed in dogs by Andrews and Workman[7], using the same stimulus-response system afterwards used in the guinea pigs, and later by Richards[8]. Eagle and Carlson[9] tabulated a very small effect of aspirin on the rat's threshold to mechanical stimulation of the tail. Hart[10] and Bonnycastle *et al.*[11] obtained definite effects in rats with respective modifications of the D'Amour–Smith[12] procedure (tail flick in response to radiant heat). Gibson *et al.*[13] reported significant effects of the sodium salt of aspirin on the threshold strength of electrical stimulation of the rat's rectal mucosa required to induce squeaking. Deneau *et al.*[14], working with experimental deep pain of calf muscles in man, exhibited a clear-cut 10–15 per cent rise in the threshold stimulus associated with aspirin administration. Benjamin[15] showed that aspirin significantly delays the time when pain terminates work being done by the human forearm deprived of circulation, and presented results suggesting that more intensive work with less precise procedures would also show aspirin effects of statistical significance.

Thus, it seems inescapable that a small and subtle anti-nociceptive effect of aspirin can be demonstrated in the laboratory with brief noxious stimulation not obviously associated with inflammation, though the conditions required are poorly understood.

Site of Experimental Antinociceptive Effect

Cook and Bonnycastle[16] could find no effect of aspirin on spinal reflexes. They[11] found that relatively large amounts were required in the chronic spinal rat, as contrasted with the intact rat, to influence the tail-flick response to radiant thermal stimulation. It is inferred that at least a portion of the acute experimental anti-nociceptive action of aspirin, perhaps varying among successful experiments, occurs at neural mechanisms above the spinal level.

In this connexion, it is classical knowledge that nociceptive responses are potentially complete at the spinal level, especially in lower species, but that in the intact animal they are under constant control of a balance of active inhibitory and excitatory influences from high levels (for example, ref. 17). Unfortunately, since Irwin *et al.*[18] pointed out that the tail flick and the skin twitch are like other nociceptive responses in this respect, many writers have spoken of these two responses as "merely spinal reflexes"[18] even in the intact animal. Winter and Flataker[19] and Bonnycastle and Cook[11,16] have commented on this error.

Possible Role of Neurological Summation

During early work on twitch in the skin of the guinea pig, we found[2] that sensitivity of the threshold stimulus intensity to morphine varied significantly with the area and duration of the radiant heat stimulus. We selected as near optimal a large area (730 mm.^{2}) and an intermediate duration (4 sec.), determining threshold intensity as the dependent parameter. With this in mind, I suggested six years ago[20] that use of a pattern of stimulus characteristics emphasizing spatial or temporal neurological summation might in some way be a factor of success in demonstration of an anti-nociceptive effect by aspirin. The area of stimulation employed by Wolff's group[6] ordinarily was about 80–310 mm.^{2}, and presumably that of Andrews and Workman[7] was similar. Hart[10] prewarmed the rat's tail subliminally, thus providing a likelihood of temporal summation. Bonnycastle[11] pointed out the probable importance of his less intense and more prolonged stimulus. Deneau's[14] pressure-cuff affected a large muscle mass. Gibson's[13] rectal electrode was relatively large. Benjamin's[15] uncirculated forearm was a considerable mass of tissue.

This will recall the well-known opinion of Wolff's group[6], based on work with liminal 'pricking pain', that pain sensation is neurologically unique in lacking the property of spatial summation. Rather, these workers' results would seem to indicate a very pronounced central occlusion of a smaller liminal field by a larger one[2], reflecting at once the poor

local sign of pain and a very efficient central convergence of excitation. Even so, spatial facilitation manifests itself near the limen, either for the subjective sensation[21] or for the nociceptive response[2].

Insufficiency of Central Anti-nociceptive Action Alone

However real, a central neural action so small and subtle as that of aspirin seems inadequate by itself to account for the efficiency with which the drug relieves natural pain. Goetzl[22] came to this conclusion on viewing his own negative experimental results with aspirin together with older work. Now there are more positive kinds of evidence.

During the past two decades many compounds of miscellaneous structure have been reported in the pharmacological literature to possess experimental anti nociceptive potencies in animals more or less superior to that of aspirin but inferior to that of codeine. Many of these have been tested clinically; but none has been generally accepted. Two such compounds with which we have worked were more powerful anti-nociceptives in guinea pigs than aspirin, and, by contrast with aspirin, were significantly though not strongly anti-nociceptive in rat tail-pinching experiments (α-piperidyl-3,4-dichlorophenylacetic acid, monohydrochloride, and 1-(1-piperidyl)-1-cyclohexanecarboxamide, monohydrochloride; synthesized by E. M. Jones and P. J. Ehrlich (1950–51); evaluated for anti-nociceptive action by J. Wax, J. Lyon, S. Kaprielian, V. Burr, M. Been and C. V. Winder (1950–54)). Yet, in natural human pain, both were significantly ($P = 0{\cdot}05$) inferior to aspirin, if, indeed, effective at all[23].

The history of salicylamide is instructive. The anti-nociceptive action of this old compound is sufficiently greater than that of aspirin to be demonstrable in many laboratories. Yet the drug's analgetic efficacy, long in doubt before the recent attention it has enjoyed, is now again in serious doubt[24]. Derivatives of salicylamide even more potent as anti-nociceptives in animals also have failed as yet of clinical acceptance, at least one being significantly[25] and another fairly probably[26] less effective than aspirin in natural pain.

It is therefore now reasonably clear that a degree of experimental central anti-nociceptive action somewhat greater than that of aspirin is not, by itself, predictive of clinical analgesia. It is conceivable, though unsupported, that the quality of central action by aspirin differs from that of many other kinds of agents in such manner that, even though small, it could account for relief of natural pain.

One consequence of this working attitude is that many of us need no longer be so concerned with boxfuls of experimental compounds having no more anti-nociceptive action than, say, salicylamide, excepting those for which evidence can be found of some adjunctive action that could potentiate a small anti-nociceptive effect in the relief of pain.

Adjunctive Anti-preinflammatory Action

Returning to aspirin in search of some adjunctive property, one sees most prominently the drug's well-established anti-rheumatic effect, a fairly specific anti-inflammatory action in the acute phases of rheumatic diseases. It could be a suppression of some rather early process—a preinflammatory process—in the course of reaction by tissue to injury. The same process could lead both to stimulation of pain endings and, eventually, to frank inflammation. It could be a process more or less common to early tissue injury associated with various kinds of natural pain. It would probably take longer to develop than the duration of most experimental noxious stimuli.

The hypothesis that a peripheral anti-preinflammatory property is essential in the relief of natural pain by aspirin gains stature on again considering salicylamide. Doubt concerning the analgetic efficacy of this agent, in spite of supra-aspirin anti-nociceptive potency, parallels doubt concerning its anti-rheumatic efficacy[24b]. A complementary test of the hypothesis is provided by aminopyrine. With a similar order of anti-nociceptive potency, the unquestioned analgetic efficacy of this drug parallels its unquestioned anti-rheumatic efficacy.

Harris proposed several years ago[27] that the pain-relieving effect of aspirin could be explained entirely in terms of a peripheral anti-inflammatory action. The present hypothesis differs in considering, rather, an anti-preinflammatory action as an adjunct which, as may become apparent later on, is probably not entirely sufficient by itself.

Adjunctive Actions of Other Kinds

It is likely that other properties of aspirin sometimes contribute to its ability to relieve mild pain. In pre-equilibrium phases of certain febrile states the antipyretic effect may relieve muscle soreness in part via reduction of muscle tonus.

The hypothetical necessity of an anti-preinflammatory action in aspirin or aminopyrine for significant relief of natural pain would, correlatively, require that another kind(s) of adjunctive action be identified in the acetanilid group. Neither acetanilid nor acetophenetidin is clearly antirheumatic in ordinary clinical doses[28], nor is N-acetyl-*p*-aminophenol known to be, yet all are considered able to relieve mild pain[24a,28]. However, all have the underlying anti-nociceptive action. Acetanilid and acetophenetidin are, perhaps, more potent than aspirin in this respect[22]. N-acetyl-*p*-aminophenol, the main metabolic intermediary of both[29] and perhaps substantially responsible for their anti-nociceptive action[30], is about equally potent[31]. Moreover, all are antipyretic[28,31] and, in addition, seem to possess a pattern of sedative and relaxing properties[4,28] that could be importantly adjunctive to the anti-nociceptive action[4].

Insufficiency of Adjunctive Properties Alone

Analgetic efficacy in the acetanilid group thus suggests an underlying importance in a mild analgetic agent of anti-nociceptive action, small and subtle though it may be. Mere absence of pyrexic malaise and muscle tension, or of anxiety, or presence of mild sedation, is not *per se* generally analgetic.

The case of phenylbutazone indicates that anti-rheumatic potency alone is insufficient for prediction of general analgetic efficacy. This drug is now well known to be the most potent anti-rheumatic agent outside the cortisone group, yet there seems to be no firm evidence for utility in relieving pain except in grossly inflammatory diseases. Correspondingly, though large intravenous doses were anti-nociceptive[32], we have been unable to detect such action at sublethal intraperitoneal doses in guinea pigs, or at a fourth the LD_{50} of the drug intraperitoneally in rats[33]. Fewer rheumatologists are now referring to phenylbutazone's 'analgetic' action, and more to its anti-inflammatory action.

Lack of known usefulness of cortisone-like agents as general-purpose analgetics may not be pertinent. These glucocorticoids possess a different kind of peripheral anti-inflammatory action[34], perhaps not impinging so specifically on particularly early reactions to tissue injury that lead directly to stimulation of pain receptors.

Thus, it has been our working hypothesis for the past few years that the small, central, anti-nociceptive action of aspirin or aminopyrine, though necessary, is not sufficient by itself for mild analgesia; but is effectively potentiated (?) by a peripheral anti-preinflammatory action related to non-steroidal anti-rheumatic action which, however, is also insufficient alone.

One interesting implication is an explanation of the old and growing clinical popularity of mixtures of codeine with aspirin, or of aspirin and acetophenetidin. The anti-nociceptive effects of the two or three agents would be additive. The more general sedative effects of codeine and acetophenetidin would, perhaps, add. The combined anti-nociceptive effect would amplify the peripheral anti-preinflammatory effect of the aspirin and the sedative effect of the codeine and acetophenetidin. The end clinical action of the combination of drugs might be somewhere between addition and multiplication of the individual drug effects.

A Laboratory Model of Pre-inflammation

For several years we have been studying the influence of drugs and chemicals on development of erythema on albino guinea pigs following exposure to ultra-violet energy[34], a procedure first employed by Wilhelmi[32,35]. This experience has strongly influenced development of the foregoing hypothesis.

In a standardized procedure wherein the erythema is developed 2 hr. after exposure, divided-dose pre-treatment with a typical non-steroidal anti-rheumatic agent delays the appearance of the erythema in a proportion of animals depending on dosage. Significantly effective divided doses of various agents in the experiment closely approach daily anti-rheumatic doses in the clinic, on a body-weight basis.

Aspirin and aminopyrine are effective in this test; they are anti-rheumatic, anti-nociceptive and analgetic. Salicylamide is not effective; it is doubtful as an anti-rheumatic, and, in spite of easily shown anti-nociceptive action, is doubtful as an analgetic. The two supra-aspirin experimental anti-nociceptives mentioned earlier that were found ineffective as clinical analgetics[23] were not effective in this test[36]. Phenylbutazone is most potently effective; it is most potently anti-rheumatic, yet not clearly anti-nociceptive and not, apparently, generally analgetic. The acetanilid group presents the same problem discussed earlier. These agents are not effective in the ultra-violet erythema test at dose-levels that would be tolerated; they are not usefully anti-rheumatic; but, nevertheless, their anti-nociceptive action apparently provides an underlying basis for mild analgesia, perhaps essentially aided by a more general action on the central nervous system.

The ultra-violet tissue injury sets off a pre-inflammatory phenomenon amenable to influence by non-steroidal anti-rheumatic agents. Presumably it is related to a pre-inflammatory phenomenon in various painful tissue states which these same agents influence when, provided they also have some central anti-nociceptive effect, they relieve pain.

Cortisone-like agents do not influence the erythema[34c], have different kinds of effects on inflammatory processes, and are neither anti-nociceptive[18] nor known to be generally useful as analgetics. The more potent analgetic agents from codeine upward do not delay the erythema and have no specific anti-rheumatic effect. Their pain-relieving actions are central and are associated with sufficiently robust experimental anti-nociceptive effects so that there is no great difficulty in comparing them in the laboratory in terms of acute, non-inflammatory pain.

One can only speculate on the nature of pre-inflammatory processes induced by noxious tissue states, leading to stimulation of pain endings and eventually to frank inflammation, and susceptible to agents like aspirin. It is conceivable that some clarification might come from work now being done in several laboratories on activation of proteases and/or globulins, formation of kinins, release of potassium, etc.[37].

More Complete Laboratory Models of Natural Pain

If the ordinary experimental noxious stimulus is, perhaps, too brief to allow development of the pre-inflammatory state upon which aspirin seems to have an essential component of its action, then it is natural to consider having this state pre-established as a part of the eventual total stimulus. We were therefore gratified to note a description by Randall and Selitto[38] of a laboratory model of inflammatory pain—measured pressure applied to the inflamed and œdematous foot of the rat. One is reminded of Schumacher's[39] earlier work on the effect of aspirin on experimental pain thresholds of inflamed human skin.

Using the inflamed foot, Randall and Selitto found sodium salicylate, acetophenetidin, N-acetyl-*p*-aminophenol, and phenylbutazone effective in raising the threshold pressure required for a nociceptive response. It is somewhat discouraging that aminopyrine was not significantly more effective than sodium salicylate—a deviation from clinical experience. It is interesting and more understandable that acetophenetidin and N-acetyl-*p*-aminophenol were only a half to a quarter as potent as sodium salicylate, even though they were more potent central anti-nociceptives as measured with the normal, uninflamed foot. This agrees with the absence either of anti-rheumatic and anti-erythemic (ultra-violet) effects of these two agents at tolerated dosage, or of any obvious means for reflexion of their adjunctive sedative properties in the results. Also, it is gratifying that phenylbutazone was only slightly more potent than sodium salicylate, and would thus be predicted to have general analgetic utility, if any, only at doses much larger than can safely be employed clinically for the anti-rheumatic effect. This agrees with the present lack of clinical evidence of general utility as an analgetic, and with absence of clear anti-nociceptive action at subtoxic doses (*supra*).

Randall and Selitto[38] suggest a liability in their model that we believe may be inherent in any involving œdema[34a]—a liability to indirect effects from vascular disturbances caused by the agent on test. It will be interesting to study the properties of a model in guinea pigs combining the relatively non-œdematous[34c] ultra-violet inflammation and the acute, wide-area radiant heat stimulus[2,3].

Recently, mice injected intraperitoneally with appropriate amounts of phenylquinone[40] or acetic acid[41] have been observed to 'writhe'[40] or 'stretch'[41]

repeatedly and for long periods. The phenomenon is suppressed by suitable doses of aspirin or aminopyrine, as well as by the more potent central analgetics. The stimulus, presumably noxious, differs in two important respects from those considered hereto. First, it is applied to a larger tissue surface, potentially bringing into play a much broader pattern of neurological convergence. Secondly, it is present for a longer time, at once providing possibilities of temporal neurological summation and of maturation of preinflammatory processes. In terms of the present thesis, any or all of these factors would improve sensitivity to agents like aspirin or aminopyrine.

High doses of acetophenetidin required to suppress writhing in one laboratory[40], and of salicylamide in another[41], recall again the poor activity of these agents as anti-rheumatics or anti-erythemics (ultraviolet) and suggest that the writhing stimulus leans to some extent on a pre-inflammatory component. Discrepancy between the two laboratories in effectiveness of sodium salicylate is puzzling. Suppression of the writhing by a variety of chemicals and drugs[41,42] renders the phenomenon rather enigmatic at present.

It may be that, with increasing attention to matters like extensity, duration and quality of stimulus, as well as to higher-level neurological conditioning[43], research workers will gradually resolve the differences between experimental and natural pain so long and vigorously emphasized by Beecher[44].

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CHANCE AND PROBABILITY

IF the fundamental concepts of mathematical probability and their role in statistical theory are still subject to sharp controversy after three centuries of discussion by the acutest minds, we can scarcely expect that the concepts of psychological probability, born within the past decade, should already have found general acceptance. It is not indeed clear to everyone where mathematical probability ends and where psychological probability begins, if it is justifiable to separate them at all. The papers presented at a session of Section J (Psychology) during the York meeting of the British Association at least shared the view that the study of psychological probability unquestionably offers important opportunities for research into hitherto unexplored realms of mind and behaviour. The three papers presented were: "Wishful Seeing in a Gambling Situation", jointly by Dr. John Beloff and Mr. Kenneth Warwick (Queen's University of Belfast), and read by the former; "Chance and Uncertainty", by Dr. W. Mays (University of Manchester), read in his absence by Dr. D. McMahon; and "The Psychology of Luck", by Prof. John Cohen (University of Manchester).

The paper by Dr. Beloff and Mr. Warwick was devoted to an experimental study of 'perceptual autism', an expression coined by Prof. Gardner Murphy in 1947 to refer to those subjectively distorted

changes in perception which have the effect of gratifying the observer's needs—in other words, wishful seeing. The context of the experiments was a type of gambling situation. As a point of departure they took various investigations by Murphy and his colleagues designed to establish the autistic phenomenon and they discussed the criticism that the observations could be explained in terms of the familiar notions of 'expectancy' or, alternatively, in terms of 'response availability' without postulating a special autistic mechanism. Thus if a hungry man, on being shown an inedible object, says that it is something edible, it does not follow that he says so because he sees it as such but merely because he would naturally be thinking of things to eat. Dr. Beloff's experiments were designed to rule out these alternative explanations.

Three distinct experiments were conducted. In the first the subject had to guess which of four possible visual stimuli would appear in a brief tachistoscopic exposure. Before each exposure the subject was told that a square (with a cross inside) would be shown with one of the sides missing, and he had to guess which one it would be. He was given money with which to bet on his guess. On the autistic hypothesis the guesses should tally with the bets on a statistically significant number of occasions.

In this first experiment there were two series of presentations, one random and one biased. In the random series, the subject presumably had no 'reason' to believe that a particular card was more likely to appear at a given trial, whereas in the biased series it was experimentally possible to distinguish between what the subject 'expected' and what he 'wanted' to appear. There was a significant autistic effect, in spite of marked individual differences in patterns of response. This led Dr. Beloff to suggest that autism is a feature of personality and, in this sense, akin to optimism.

In order to meet the possible objection that this outcome was due to 'response availability', the second experiment introduced a new series which required the subject to bet on the card which he expected *not* to appear, and to forfeit his bet if it did. The reward series again revealed an autistic effect but not the penalty series, the bet-guess correspondence being at chance-level.

In the third experiment a further attempt was made to ensure that the hypothesis of 'expectancy' could be eliminated by depriving the subject of the power of deciding which of the four cards was to be rewarded. The subject now won his bet if the stimulus corresponded to a particular counter drawn at random in advance of the exposure. This experiment seemed to show clearly that "once desire is divorced from expectancy by introducing an *arbitrary* system of rewards and penalties, the autistic effect no longer operates". Without denying that emotions may influence perception autistically, Dr. Beloff concluded that there is no need to assume a special central determinant, as proposed by Prof. Murphy.

Dr. Mays's paper discussed certain logical and psychological issues arising in the study of probability in general. He began by referring to Venn's views expressed in his "Logic of Chance" (1876) and passed on to a more detailed criticism of Prof. S. E. Toulmin's contribution to an Aristotelian Society symposium on probability in 1950. As to Prof. Toulmin's question of the meaning of 'probability', Dr. Mays stated: "the answer is probably very little, since it refers to a generalized situation, not always specifiable by concrete operations". In his view, Prof. Toulmin under-estimated the extent to which adult thinking is permeated by technical ideas deriving from games of chance.

Dr. Mays stated that psychologists had studied the pragmatic understanding of probability from two points of view: that of methodology and that of concept formation. He thought that the initial impulse to study subjective probability had come from experiments on extra-sensory perception, and suggested that descriptions of the way people behave in experimental probability situations ought not to be taken as a guide to rational behaviour, that is, as ethical norms, which subjective probability, in the sense used by Ramsey and Savage, is evidently meant to be.

Much of Dr. Mays's paper took the form of a critical résumé of the views of certain psychologists, notably Goodfellow and Piaget. The main feature of Piaget's work, he declared, is to take "the abstract calculus of probabilities as an objective standard of mature behaviour, and deviations from it (the so-called illusions) as a mark of immaturity". The concept of 'chance', according to Piaget, is not an intellectual intuition, but has to be learnt; since the child endeavours to find a causal factor in everything he observes, he cannot apply the notion of equi-possibility of probability situations. The child's notion of probability, in Piaget's view, only appears when he has built up a system of logical operations enabling him to contemplate possibilities (in terms of combinations and permutations) beyond what actually happens.

Dr. Mays believes that there is little to be said in favour of the belief in a special type of subjective probability postulated to cover what he described as "really an amalgam of emotional attitudes, intellectual systems, etc.", an approach which reminded him "of the instinct psychologists and the Aristotelians who postulated a new type of instinct for every form of behaviour".

Prof. Cohen placed the study of luck in the context of psychological probability. The belief in luck, he suggested, originated in the attempt to master life's uncertainties. As societies become more civilized their uncertainties do not diminish. Hence the idea of luck survives with full vitality. The examination of luck formed part of a systematic series of studies, initiated at Manchester in 1952, into those forms of thought and behaviour which characterize states of uncertainty: choice, estimation, prediction, inference, risk-taking, and decision-making generally; and the method of investigation was at once experimental and developmental. He ventured to make two inferences from his earlier inquiries which had a bearing on the present one. First, the idea of 'randomness' is alien to the human mind, which is essentially pattern-seeking or, in more general terms, engaged in an implicit or explicit search for meaning. Secondly, there is evidence that our minds act as unwitting 'computers' and, under certain conditions, an analogy can be drawn between quasi-additive and quasi-multiplicative operations in psychological probability and the fundamental properties of mathematical probability.

Prof. Cohen then considered the meaning of 'luck' in terms of observed usage, principally in the twofold sense of 'unearned advantage' and 'fortuitous intervention'. He illustrated the survival of beliefs in luck by reference to the fact (as he had found) that young and old alike still have their lucky colours,

days and numbers. Moreover, people are believed to have stores of luck which can be depleted and replenished, and there is evidence that women felt themselves to be luckier than men.

Prof. Cohen was mainly concerned to describe experimental demonstrations of the effect of a belief in luck on expected performance and achievement. Thus, a subject could estimate realistically his likely performance at any given task. This estimate could then be compared with other estimates of his likely performance if he thought he would be (*a*) lucky, (*b*) very lucky, (*c*) unlucky, (*d*) very unlucky. From a variety of experiments of this kind it seemed that, within a given range of tasks, to be lucky signified an expected improvement in performance of some 10 per cent, and to be very lucky, of 20 per cent. Unluck meant an expected deterioration of 30 per cent and very bad luck anything up to 80 per cent.

An allied effect of the belief in luck could be measured in terms of the proportion of attempts in which the subject expected to succeed at particular tasks varying in level of difficulty. Here, too, the pattern of realistic estimates could be compared with the pattern of estimates of success with varying degrees of expected luck and unluck. Psychological probabilities derived in this fashion revealed that when tasks are of comparable subjective difficulty the patterns of estimates of expected performance bear a striking mutual resemblance. Furthermore, a pessimistic under-estimation of one's capacity appeared when the task seemed subjectively easy and an optimistic over-estimation when it seemed hard. A generalization of particular interest could be embodied in the formula :

$$\psi_l^p \quad + \quad \psi_{\bar{l}}^{1-p} = 1$$

where ψ represents the psychological probability, p the *a priori* probability of success, and l (and $\bar{l}$) the degree of luck (or unluck) to which the original estimate relates. What is conveyed by this formula is the empirical observation, based on many experiments, of the quasi-additive character of psychological probabilities. Suppose, for example, that the *a priori* probability of a subject's success at a task is 0·1, and that his corresponding psychological probability, if he thinks he will be very 'lucky', is 0·6 ; then when the *a priori* value of success at a similar task is 0·9, his psychological probability of success if he thinks he will be very 'unlucky' turns out to be approximately 0·4. The additive property appears when the values of ψ are derived from estimates made after as well as in advance of performance.

A different analysis was employed by Prof. Cohen to measure the frequency with which we think good or ill fortune will befall us. In his experiments, the estimate of performance which is regarded as most realistic is expected by the subject to occur on some 52 per cent of the occasions, the lucky (or unlucky) outcome on some 17 per cent and the very lucky (or very unlucky) outcome on some 7 per cent. These experiments, Prof. Cohen believes, shed light on the basis of our aspirations. For in everyday life we are often governed by unrealistic considerations, and what we are, in fact, prepared to undertake may depend basically on what we imagine we should achieve if we were lucky or unlucky. The range and pattern of psychological probabilities might justify the assumption of a sort of inner 'standard deviation' of judgment.

Prof. Cohen also spoke at some length of social repercussions of a belief in luck, particularly as a stabilizer in allaying socio-economic envy, and in discouraging initiative ; and he referred to the 'magical' significance of the practice of disparagement, both of self and of others. In conclusion, he drew a parallel between individual and cultural psychological probability, in that the phenomenon of pseudo-subjective dependence (or the Monte Carlo fallacy) has its analogue in the cyclic, as contrasted with the linear, conception of time and history which characterizes traditional and archaic cultures.

COAST EROSION AND ACCRETION

IT is almost true to say that, despite the full and interesting reports of the Royal Commission on Coast Erosion (1907–11), little effective action on the coasts of Britain was taken until the severe flooding of 1953 occurred. A Departmental Committee was then appointed under the chairmanship of the late Lord Waverley, and in 1954 made two relatively short reports containing a number of recommendations. Three of them are particularly relevant to this article. No. 10 reads : "that steps should be taken to ensure proper co-ordination of researches. Recourse might well be had for this purpose to the constitution of two consultative and advisory standing committees. There should be close co-operation on research matters between British and Dutch scientists, engineers and Governments". Recommendations 2 and 3 emphasized the necessity of research into "the behaviour and suitability of vegetation for use on sand, shingle and other material adjacent to the sea", and "the urgency of research into the movements of beach material, off-shore banks and related coastal problems". Thus the discussion organized by Sections E (Geography) and K (Botany) at the recent British Association meeting at York was particularly relevant.

The two standing committees referred to have been formed, and the one devoted to sea defences is that most concerned with this article. The other is primarily concerned with tidal and oceanographical matters. The sea defence committee, under the chairmanship of Mr. E. A. G. Johnson, of the Ministry of Agriculture, Fisheries and Food, has already made three reports to the Ministers concerned (Agriculture, Fisheries and Food, Housing and Local Government, and the Secretary of State for Scotland). The committee is very alive to the physical and ecological problems affecting our coast, and Mr. G. Cole, who acts as secretary, was one of the speakers at York. It is the first time in Britain that such complete co-ordination on coastal problems has been attained. Mainly through the personnel of the committee very close contact is maintained with the Hydraulics Research Board, the Nature Conservancy, the Building Research Station (in connexion with sea-wall and sea-bank construction), and the universities. Since, too, radioactive and other tracers are becoming more and more significant

in coastal work, there is also a close link with Harwell.

In practice the erection of sea defences of one kind or another is the work of engineers, either consultants or those connected with river boards, or local or national authorities. But all who are interested in the coast are concerned among other matters with the source, supply and maintenance of beach material, and with the holding of dunes and the formation of marsh. Experience has shown all too often that indiscriminate building of groynes and walls may have very serious effects in other places. Since the natural protection of much of our coast is a good beach, it is all important to study how it is to be maintained. Careful surveys made by members of the Department of Geography at Nottingham showed that it took 5 or 6 years before the Lincolnshire beaches were restored fully to the level they reached before the 1953 flood scoured them almost completely. In many cases it is possible to assume with a fair degree of certainty that a beach is fed by lateral transport. If this is interfered with at some locality, sites to leeward are bound to suffer. But there are places, for example Scolt Head Island, where it is not unreasonable to assume that new material comes more from offshore than alongshore. This matter of offshore supply is one that is frequently debated, and one that perhaps can be finally settled only by tracer or aqualung methods. Already some useful results based on observations by divers have been obtained at Scripps Institute of Oceanography and a beginning has been made in Britain by the physiographic unit of the Nature Conservancy. Careful observations by trained men in water down to a depth of perhaps 100 feet may help very greatly in many shore problems. These more recent methods of approaching the question of supplies of beach material do not in any way mean that the type of studies already in use should be discontinued. Far from it; they should be pursued vigorously, and to 'know' a beach implies a long study. It may sometimes be necessary in building defences to act hurriedly, and it may happen that the result is successful. In general, however, the study of a beach over a period including all types of weather likely to act upon it is desirable. Moreover, it is also valuable to be able to make comparative studies. Conditions are never exactly the same in any two places, but a great deal can be learned by studying comparable localities on different parts of the coast.

The four papers that followed the introductory remarks dealt mainly with specific problems and places. Dr. M. C. Pearson, of the University of Nottingham, discussed the biology of the sea buckthorn (*Hippophae rhamnoides*). This shrub enters the succession of sand-binding plants after the marram grass stage. It is found in Britain only on coastal sand dunes, and is common on certain parts of the east coast. Dr. Pearson's studies have been made at Gibraltar Point, a nature reserve at the north-eastern corner of the Wash. It has been found that most of the plants originate from underground stems and but very few from seed. This is partly explained as a result of the predation of seeds by birds and small mammals. The shrub carries big spines, and so may form a deterrent to grazing animals and even to picnickers. In that sense it may have value in keeping certain parts of the dunes free from erosion caused by trampling. In any event it is of value in fixing the dunes, and it is used partly in that way in Holland. Further research work on this interesting species is planned.

Mr. Cole's paper was concerned with the gathering and stabilizing of sands, silts and clays by vegetation. He pointed out that only along a relatively short distance (60–70 miles) of the total length of the coast of England and Wales do dunes form the sole or partial defence, and salt marshes cover even less distance. He discussed several interesting examples of the artificial accumulation of sand dunes around brushwood or other type of fencing or obstacle, and also the effect of various grasses in their relation to dune and marsh growth. The remarkable growing power of marram was pointed out, but he stressed the view that its ramifying and long roots may have little effect in binding the sand. The building of a new dune by British Railways at Dawlish Warren, and the planting on it of tree lupin (*Lupinus arboreus*) following the marram, was taken as a good example of the artificial production and maintenance of sand dunes.

In the development of marshes the planting of *Spartina* was mentioned. This grass has spread rapidly on the south coast and is now invading, sometimes all too successfully, the east coast. Dr. D. Ranwell, of the Nature Conservancy, has recently been engaged upon methods for its eradication. It will be noted that *Spartina* in this paragraph is not followed by any specific name. Dr. C. E. Hubbard, of Kew, has shown that the grass which has grown so extensively in Southampton Water and is regularly used for planting and reclamation elsewhere is not *S. townsendii* but rather a chance offspring of that plant, and that so far it has not been given a specific name.

Mr. Cole very rightly made the point that it is wrong to rely too much on one or two species. If for some reason disease developed in marram or *Spartina* grave difficulties might arise. There should be experimentation with vegetation and, in certain carefully controlled circumstances, we should introduce foreign species. The idea of a 'coastal garden' in which such experiments could be made has already been adumbrated.

Mr. C. Kidson was also concerned with this same point. He has studied certain parts of the coast in great detail, and as physiographer of the Nature Conservancy he has been able to make comparisons with many other parts. His studies on the Somerset coast have shown the value of *Spartina* in accumulating sand and silt, and it is estimated that in part of Bridgwater Bay the level of the foreshore has been raised 5–7 feet since 1928. But here again all is not as it should be. *Spartina* may act locally almost like a groyne, and it is able to hold up the longshore transport of shingle. In one place 60 feet of spartinetum was overridden by shingle in one year. The shingle beach behind, cut off from its supply, was combed down in big storms and became lower and so less of a protection to the land behind. Mr. Kidson also directed attention to the interesting work that is now being carried out along the west coast of Denmark. There the foreshore has been built up by *Salicornia* spp. and *Puccinellia maritima*. Their spread has been much aided by the building of low brushwood dams and shallow drainage channels. He also directed attention to the possibility of *Suaeda fruticosa* holding mobile shingle. It is a habit of this shrub to grow at the head of marshes and at the foot of shingle ridges. Prof. Oliver, in his studies of Blakeney Point, directed attention to it many years ago. It is doubtful if the plant can be a real deterrent to shingle movement.

The remaining paper, although given earlier in the sequence, dealt with the coast of part of Lancashire.

Mr. Gresswell, of the University of Liverpool, has made several extensive studies of this. It is put last here because it was rather less concerned with vegetation than were the others. Nevertheless, South Lancashire is faced with a dune coast, and one made use of perhaps more than any other dune area in these islands. The speaker discussed the erosion at Formby and the accretion at Southport. This coast illustrates extremely well how difficult it is to estimate what will happen in the future. Formby and district have been suffering loss for some 50 years; before then the same area was gaining at about the rate it is now losing. Inland of Southport and Formby is a belt of rich agricultural land below the level of high tides, and only protected by the dune belt. The dunes have long been controlled, and extensive pine forests cover part of them. But these will not stop erosion. Extensive sea walls may do so, and in a limited way so also may bulk accumulation—the artificial gathering of sand by brushwood groynes and careful planting. This will increase the amount to be eroded by the waves; it cannot stop the erosion. It may also be possible to raise the height of the beach by building groynes and stopping the sand which moves both to north and to south away from Formby. But then how will this affect Southport? The lesson has been learnt a little farther north: the protection of Blackpool has starved the beaches at Fleetwood and caused severe damage there.

Change is constant along the coast; it is most noticeable in those parts faced by soft cliffs or by low-lying ground fringed by dunes and marshes. It is much slower, and perhaps not measurable in a life-time, on a coast faced by cliffs of resistant rock. Coastal studies are not only of significance to all dwellers along the sea and owners of land adjacent to it, but they are also of particular interest to workers in many branches of science, archæology and history. Coastal defence, in the long run, must benefit by the more leisurely rate at which certain experimental work has to be undertaken. Botanists, physiographers and others, of several of our universities, are now much concerned with coastal research, and their findings are appearing with some regularity. The more we know of any particular stretch, the more certain will be the effect of any future defence work that may be necessary. The four papers presented at the meeting of the British Association at York may be regarded as samples of the interest which coastal research is now provoking. J. A. STEERS

OBSERVATIONS OF THE RUSSIAN MOON ROCKET
LUNIK II

THE 250-ft. radio telescope at Jodrell Bank was used to receive the transmissions from the second Moon rocket launched by the U.S.S.R. Observations were made on the evenings of 1959 September 12 and 13 on frequencies of approximately 183·6 Mc./s. and 19·992 Mc./s. The only other part of the radio spectrum searched was in the region 19·99–20·01 Mc./s., but no signals from the probe were found.

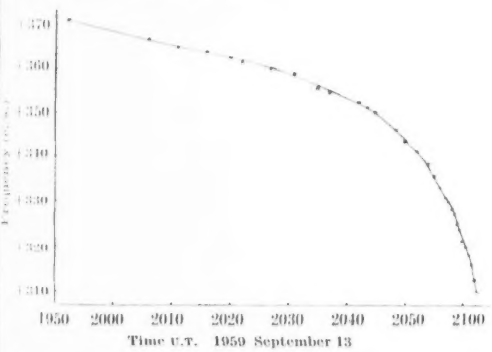

Fig. 1. The variation of received frequency in cycles per second deviation from 19·992 Mc./s. plotted for the last hour of the flight of *Lunik II*

The primary feeds consisted of a folded-wire dipole without reflector for the 20 Mc./s. band and a folded dipole with reflector for 183·6 Mc./s. The 183·6 Mc./s. signal was received on a communication receiver with a band-width of 5 kc./s., and the 19·992 Mc./s. on a receiver with variable band-width, 750 c./s. being employed for most of the time. Both frequencies carried the familiar 'bleep bleep' modulation pattern, and although clearly audible, the signals were not strong enough to permit reliable estimates of signal strength. The signals on both frequencies ended abruptly and simultaneously at 21h. 02m. 23s. U.T. on September 13.

Within the limits of the 2° beam of the radio telescope at 183 Mc./s., and the rather heavy fading of the weak signals, there was no significant deviation of the position of the rocket from the predictions received from Moscow.

The precise frequency of the 19·992 Mc./s. signal was measured by comparison with a frequency standard to an accuracy of $\pm\frac{1}{2}$ c./s. On the evening of September 12 the measured frequency varied uniformly at 4 c./s. per hour between 20h. 30m. and 22h. 30m. U.T. The rate expected from the effect of the Earth's rotation alone is about 6 c./s. per hour; thus the rocket was at that time being slightly retarded by the Earth's gravitational attraction. The variation in frequency over the final hour of the rocket's journey on September 13 is plotted in Fig. 1. The smooth nature of this curve indicates that no guiding rockets were used during this period. The slope of this curve is a direct measure of the line of sight acceleration and hence, using the Moon's mass, gives a maximum distance from the Moon for each point on the curve. The acceleration at the end of the curve is that expected for an object moving directly towards the centre of the Moon at a height of 70 km. ± 150 km. from the Moon's surface, and can therefore be taken as positive confirmation that the rocket did indeed hit the Moon somewhere within 7 minutes of arc from the centre of the lunar disk. The velocity of impact derived from these data is approximately 3 km./sec. ± 0·5 km./sec.

We are indebted to our Russian colleagues for computing the tracking data for the radio telescope.

J. G. Davies
A. C. B. Lovell

Jodrell Bank Experimental Station,
University of Manchester.

On September 13, attempts were made to observe the impact of the Russian vehicle upon the Moon. The telescope used was the 12·5-in. reflector with which extensive lunar observation has been carried out since 1949.

The impact area had been indicated as that of the Maria Serenitatis, Tranquillitatis and Vaporum. Such an area would be impossible to cover adequately. Since it seemed reasonable to assume that the Russians intended to land the vehicle as close as possible to the apparent centre of the lunar disk, it was considered best to use a reasonably high power (×300 to 400) and concentrate solely upon the Mare Vaporum region.

Predicted impact time was 21h. 01m. U.T. Nothing was recorded at this time, but at 21h. 02m. 23s. U.T. (±2 sec.) a minute pinpoint of light was recorded; it appeared suddenly, and faded out within half a second. The lunar co-ordinates are estimated as +085 +195. This places the position as in the Hyginus area, close to Schneckenberg.

Though seeing conditions were good, the phenomenon was so uncertain and so close to the limit of visibility that it seemed unwise to trust it. A report was at once sent to the Director of the Lunar Section of the British Astronomical Association, at Manchester, to await confirmation. Since it now seems that both time and position are in good agreement with other observations, there is a possibility that the phenomenon did in fact represent the impact.

Patrick Moore

Glencathara, Worsted Lane,
East Grinstead, Sussex.

On September 13, observations were made with the hope of observing the landing of the Russian *Lunik* on the Moon, using a reflecting telescope of 15¼-in. aperture with a power of 300. The sky was very clear and surface details on the Moon clearly defined. The Russians had said it was aimed at the Mare Tranquillitatis, Serenitatis and Vaporum, that is, the region to the north-west of the geometrical centre. Last Sunday the Moon had sufficient libration to bring this region nearer to the centre as seen from the Earth than usual.

This area of hundreds of square miles was 'swept' regularly. The stated time for impact arrived and nothing was seen. I decided to continue for a short while and 1½ min. after the stated time, at 21h. 02m. 23s. U.T., I was looking at the Mare Vaporum, the nearest part to the centre. At this point, north of the Hyginus Cleft and close to Schneckenberg, I observed a pinpoint of light and a kind of dark ring just as though dust had been disturbed and heated. This lasted a few seconds.

I understand that this observation is in accordance with the work of other observers.

H. Percy Wilkins

35 Fairlawn Avenue,
Bexleyheath, Kent.

NEWS and VIEWS

Engineering in the University of Birmingham: Prof. G. F. Mucklow

Prof. G. F. Mucklow retired this summer from the Chance chair of mechanical engineering, University of Birmingham. He is succeeded by Dr. S. A. Tobias, assistant director of research in the Department of Engineering, University of Cambridge. Prof. Mucklow has held the chair since 1940. He was educated at Rugby, McGill University and the University of Manchester. He was for a short time a research associate of British Motor and Allied Manufacturers before taking up the post in 1923 as lecturer in engineering at the University of Manchester. He is well known for his work on compression-ignition engines: super-charging, exhaust pipe effects, wave-action in gases and related topics. During his tenure of the Chance chair, the Department of Mechanical Engineering has been greatly expanded. Prof. Mucklow has played a prominent part in the development of postgraduate courses of instruction for men returning from industry. The first course to be established was that in production engineering, and this was followed in 1950 by a most successful course in thermodynamics. He has seen the Department rehoused in excellent buildings which were officially opened in 1954.

Prof. S. A. Tobias

Dr. S. A. Tobias, who succeeds Prof. Mucklow, was born in Vienna in 1930. He received his education at the University for Technological and Economic Sciences, Budapest, Hungary, and graduated in 1943. For four years after that he worked in industry as a design engineer of machine tools. Tobias came to Britain in 1947 as a British Council Scholar, becoming a research student in the Department of Engineering, University of Edinburgh, where he received his Ph.D. in 1950. During 1951–54 he was an Imperial Chemical Industries research fellow at Edinburgh, working on problems of linear and non-linear vibrations, and received his D.Sc. Edinburgh in 1955. In that year he was appointed assistant director of research in the Department of Engineering, University of Cambridge, where he has built up a flourishing research school in the field of non-linear vibrations and in problems arising in metal-cutting processes.

Agricultural Botany at Bangor: Prof. Alun Roberts

Prof. R. Alun Roberts is retiring from the chair of agricultural botany at the University College of North Wales, Bangor. At Bangor the Departments of Agriculture, Agricultural Botany and Agricultural Chemistry are separate and independent, and, unlike most of the other universities where agriculture is taught, there are no subordinate professorships in those subjects. Prof. Alun Roberts was appointed professor at Bangor in 1945, where he had been independent lecturer in agricultural botany during 1921–40, when he was seconded as executive

officer to the Caernarvonshire War Agricultural Executive Committee. His secondment was later transferred to the Welsh Department of the Ministry of Education, in order to study its problems in rural Wales. Plant ecology, especially of the grasslands of Snowdonia, has been the favourite subject of research of Prof. Alun Roberts and his colleagues. His knowledge of early settlements and of Welsh history, enriched by long and close study of old estate manuscripts, enabled him to link up ecological changes with past land use. Particulars of early settlements, and later stocking of lowland and upland, with summer migration of the inhabitants from Hendre to Hafod, have added interest to his ecological studies. In addition to his scientific, historical and literary activities, he has found the time to serve on such bodies as the Royal Commission on Common Lands, the Welsh Land Sub-Commission and Nature Conservancy. His knowledge of land use, past and present, makes him a specially valuable member.

Prof. J. L. Harper

Dr. J. L. Harper has been appointed to succeed Prof. Alun Roberts. He gained honours in the final honours school of botany in 1946 at Magdalen College, Oxford, and was awarded the senior Mackinnon scholarship and a Department of Scientific and Industrial Research postgraduate scholarship. In 1949 he carried out research at the Imperial College of Tropical Agriculture and Colonial Microbiological Research Institute, Trinidad. He gained his D.Phil. in 1950 for his work in the interactions of soil micro-organisms. Dr. Harper is a lecturer in agriculture at University College, Oxford, and has been a member of the Board of the Faculty of Agriculture and Forestry since 1957. While he has published much in the realms of plant pathology and of genetics, he is perhaps best known for his researches in experimental ecology. By inclination and practice he is an ecologist in the widest sense, and from an agricultural point of view, in matters of weeds, prefers to start with the biology of control rather than with chemical applications. Dr. Harper, who gained a Rockefeller Foundation award, is at present working in the Department of Dr. G. Ledyard Stebbins, Davis University, California; he will not take up his appointment at Bangor until next year.

Ministry of Agriculture, Fisheries and Food: Dr. H. R. Barnell

The Ministry of Agriculture, Fisheries and Food has announced the appointment of Dr. H. R. Barnell as chief scientific adviser (food) in succession to Dr. N. C. Wright (see *Nature*, 182, 631; 1958), who has been appointed to the office of deputy director-general of the Food and Agriculture Organization of the United Nations.

Dr. Barnell was educated at Luton Grammar School and at Downing College, Cambridge. In 1929 he obtained first-class honours in the Natural Sciences Tripos Pt. II (Botany) and was awarded the Frank Smart Prize. He was afterwards Frank Smart Student in botany. He was a research student in the Cambridge Department of Botany from 1929 to 1932. After a period as research assistant and lecturer in the Cambridge School of Agriculture he was appointed to the staff of the Low-Temperature Research Station of the Imperial College of Tropical Agriculture, Trinidad. His work in Cambridge was on the biochemistry of cereals, and in Trinidad primarily on the biochemistry of the banana in relation to the refrigerated and gas storage of tropical fruits. In 1943 he returned to the United Kingdom as a member of the Dehydration Division of the Ministry of Food, and was eventually transferred to the Scientific Adviser's Division, where he was primarily concerned with developments within fields of food science and technology. In this connexion he not only played a major part in developing the food aspects of Commonwealth defence science, but also was largely responsible for initiating and planning the programme of work of the Ministry's Experimental Factory and Research Establishment at Aberdeen. In 1950 he was appointed deputy chief scientific adviser.

In the course of his official work Dr. Barnell has made wide and warm personal contacts throughout the food industry, not only in Britain but also overseas, where he has travelled extensively in North America, Central and South Africa, Australia and India. He has served on the governing bodies of a number of food industry's research associations, and was one of the Ministry's assessors on the Food Investigation Board of the Department of Scientific and Industrial Research. He is a member of council of the Institute of Biology. Dr. Barnell's outstanding contributions in the building up of the Scientific Adviser's Division make his choice as chief scientific adviser a particularly appropriate one.

Difficulties in the Present Systems of Superannuation

A question was raised in the House of Commons on July 2 regarding difficulties in the exchange of teachers between universities and colleges of technology arising out of their differing schemes of superannuation. In reply Sir Edward Boyle, Parliamentary Secretary to the Ministry of Education, said that the possibility of transfer between the two superannuation systems had been exhaustively considered and found to be impracticable. There were, however, arrangements for integrating service under the two schemes and he believed these were not as widely understood as they might be. Sir Edward Boyle said he was investigating the matter. Transfer had proved impracticable because the pensions under the university scheme were based on an insurance policy and differed in content and kind from those under public service superannuation schemes. Mr. Allen pointed out that to fill vacancies in the colleges of advanced technology and the regional technical colleges it will be necessary to go to the universities for the senior posts. However, at present the difference between the two schemes was causing many suitable university candidates to decline posts as principals and heads of departments in colleges of technology.

The Zero Gradient Synchrotron

In a press report dated June 27, 1959, the U.S. Atomic Energy Commission gives details of a large orbital accelerator for protons, to be constructed at the Argonne National Laboratory, Lemont, Illinois. Economic factors always entail a compromise between high energy and high intensity in proton synchrotrons, but improvements in design may materially enhance the output obtainable at a given cost. The technical advance known as alternating-gradient focusing led to the design of the 25 GeV. proton accelerators at Cern, Geneva, and at Brookhaven, but these machines may prove to be limited in beam intensity to about 10^{11} particles per acceleration pulse. In the Argonne Laboratory machine,

gradient focusing is not used and the uniform guiding magnetic field is forced beyond the saturation value over a vacuum system of relatively large aperture. Beam stability is obtained by wedge-focusing effects at the boundaries of the sectors into which the 200-ft. diameter magnet ring is divided. As a result of the fairly large aperture and high injection energy (50 MeV.), pulses of about 10^{12} protons of an energy of 12·5 GeV. are expected. Much of this beam should be available outside the machine.

The Argonne Zero Gradient Synchrotron and its associated equipment will cost 29 million dollars. It will provide a strong source of all known particles and anti-particles and, since it will be especially suited to the study of rare events, it may lead to the discovery of new phenomena. The cost of such research now far exceeds the resources of individual institutions, and the development of great national or international laboratories, in which many university teams conduct research with one accelerator, is a natural consequence. The new undertaking at Argonne, which it is hoped to complete during 1962–63, has many similarities to that at Harwell, where a 7 GeV. proton synchrotron is under construction for the National Institute for Research in Nuclear Science.

Higher Education in the U.S.S.R.

A bibliographical survey of technical and vocational education in the U.S.S.R. by M. I. Movšovič, issued as No. 30 of educational studies and documents by the United Nations Educational Scientific and Cultural Organization (Technical and Vocational Education in the U.S.S.R.: a Bibliographical Survey. By M. I. Movšovič. Pp. 53. Paris: Unesco; London: H.M. Stationery Office, 1959. 5*s.* net), covers vocational education at the elementary, secondary and higher levels. Besides books and articles, bibliographies and periodicals are dealt with in a separate section. Generally, publications are presented chronologically within each section and the articles are fairly fully annotated or summarized.

Planning in Pakistan

A broadsheet, "Planning in Pakistan" (*Planning*, Vol. 25, No. 433, April 20, 1959. Pp. 85–112. London: Political and Economic Planning, 1959. 2*s.* 6*d.*), which emphasizes the stimulus to central economic planning derived in the new countries of Asia from independence and the prospect of foreign aid, gives a clear but concise account of the progress of planning in Pakistan. After reviewing the effects of partition and planning in the early years, the broadsheet outlines the Five Year Plan, published in May 1956 by the Pakistan Planning Board established in July 1953, and then describes the performance and prospects of the plan. Political and Economic Planning concludes that although Pakistan is passing through a difficult phase in its economic, as in its political, development, it is tackling its difficulties with vigour. Performance, however, in some spheres remarkably good, has been uneven, and, regarded as a whole, inadequate. Big mistakes have been made, particularly because of over-ambitious schemes, and too optimistic assumptions about foreign exchange and sterling earnings, and import savings. Brilliant results in industrial development do not balance the failure to develop agriculture. Nevertheless, Pakistan's economy is basically sound. It is learning from past errors and preserving its zeal to plan and work for prosperity.

International Council of Museums

The fifth General Conference of the International Council of Museums was held in Stockholm during July 1–8 under the presidency of Dr. Georges Salles (France). The Conference was preceded by meetings of certain committees and commissions held at Oslo and Copenhagen. Dr. Torsten Althin was chairman of the Swedish National Committee which carried out all the complicated organization for the meeting. About 350 delegates attended. The theme of the Conference and the lectures was "Museums as Mirrors —their Potentialities and Limitations". An important session dealt with the inauguration of the International Centre for the study of the preservation and restoration of cultural property. This Centre, established in Rome by the General Conference of Unesco, is designed to strengthen relations between all who are interested in the preservation of their cultural traditions. Dr. H. J. Plenderleith, recently of the British Museum, has been appointed the first director, and at Stockholm he outlined the policy of this new Centre. It aims to collect documentation on the efforts already made in this field, co-ordinate research in order to avoid overlapping, and give advice to all those requesting it. The Centre will also assist and facilitate the training of experts and is destined to become the institution best informed about the results already achieved and the research in progress. The foremost requirement at present is that the great countries should support this venture and ensure its existence after the period guaranteed by Unesco. It was agreed that the next triennial conference should take place in Holland in 1962 under the presidency of Sir Philip Hendy (National Gallery, London).

Geophysical Journal

The appearance of the first number of the second volume of the *Geophysical Journal*, published by the Royal Astronomical Society, is a suitable opportunity to stress the contribution which this journal is making to the growth of pure geophysical research, especially in Great Britain. The fundamental importance of the papers, the careful refereeing and the speedy publication are heartening. Half this particular number contains original material. The other half consists mainly of a review of palæomagnetism and two shorter reports, one on a geophysical meeting and one on current geophysical research in Canada.

The Australian Journal of Statistics

The Statistical Society of New South Wales is publishing a new journal, namely, *The Australian Journal of Statistics*. It is to be issued three times a year, and will contain material relating to statistical theory and methods and their application to all branches of learning. The *Journal* will give Australian statisticians an opportunity to present their work to the public without undue delay. The editor is H. O. Lancaster. The first number runs to thirty-four pages, and besides introductory material and a "News and Notes" page, contains three papers. The price of this number is 10*s.*, which is perhaps a little high for such a slim volume, but even so the Society has had to have outside financial support from some dozen organizations. The *Journal* will no doubt satisfy a need among Australian statisticians, who are making valuable contributions to the development of statistics, and every success is to be wished to the Society in its new venture.

Soviet Rubber Technology

THE appearance of a regular translation of the monthly Soviet journal *Kauchuk i Rezina* under the title *Soviet Rubber Technology* (No. 1, June 1959. English translation of *Kauchuk i Rezina*, Vol. 18, January 1959. Pp. 64. Annual subscription rates: Ordinary, U.K. £10 10*s*. Abroad 50 U.S. dollars, or equivalent. R.A.B.R.M. Members and U.K. non-profit-making institutions £5 5*s*. Obtainable from Maclaren and Sons, Ltd., 131 Great Suffolk Street, London, S.E.1) is a welcome addition to the scientific literature of the U.S.S.R. available in the English language. The translation, which is being carried out by the Research Association of British Rubber Manufacturers under the auspices of the Department of Scientific and Industrial Research Translations Unit, combines technical competence and accuracy with a pleasant and readable style. It is stated that the journal "deals with the efficient use of raw material, the automation of manufacturing processes in the rubber industry and improvements to the design of tyres and industrial rubber goods. Articles describing the most important chemical research of interest to the rubber industry are also included". The first issue includes, in addition to original research contributions, more general articles reviewing industrial organization in the U.S.S.R., and news items. The scientific papers are about equally divided between chemistry (polymerization processes, compounding, vulcanization, etc.) and physics (properties of rubber compounds, fatigue and adhesion of tyre cord, etc.). The journal gives a good general insight into the technical and industrial problems of the Soviet rubber industry.

The Wellcome Trust

THE second report of the Wellcome Trust covers the period September 1, 1956–August 31, 1958 (Pp. 72 + 3 plates. London: The Wellcome Trust, 1959), in which £1,059,919 was allocated by the Trustees, compared with £1,170,164 in the twenty years 1937–56 covered by the first report. The fourth and final report on the findings of the Wellcome Marston Archæological Research Expedition to the Near East, published in June 1958, deals further with excavations undertaken by the late Mr. J. L. Starkey and others at a mound known as Tell el-Duwier, about half-way between Jerusalem and Gaza. Total expenditure by the Trustees on the Lachish expedition, including costs of publication, has amounted to £35,496. During the period 1956–58 grants made in aid of research in human and animal medicine and the contributory sciences have totalled £925,357. In making these grants the Trustees have followed their previous policy of supporting enterprises the merits of which were endorsed by the best available scientific opinion, but which had not hitherto received the help they needed. Priority was given to tropical medicine, pharmacology, pharmacy, therapeutics, veterinary medicine and the history of medicine. The report contains a full list of research grants and of travel grants during the period. Travel grants were made to 167 research workers, expenditure increasing from £11,410 in 1955–56 to £20,022 in 1957–58 and in addition five block grants were made to the organizing committees of international congresses or of smaller specialist symposia abroad, bringing the total expenditure to £42,175 on 257 persons in the period. The Trustees have also instituted a system with the Carlsberg Foundation of 'Carlsberg-Wellcome Travelling Research Fellowships' to encourage friendly co-operation on an exchange basis between Danish and British research workers in sciences bearing on human and animal medicine and two fellowships were awarded in each of the academic years 1957–58 and 1958–59. Capital grants for building projects during the period amounted to £543,500, with a further £115,160 to assist medical research libraries and museums, which included some building projects, and a further £171,065 allocated for expenditure on major items of research equipment. In support or endowment of senior research posts the Trustees allocated £72,983, and towards various grants for research expenses and assistance, £25,107. New grants totalling £3,932 were made for work in the history of medicine and £957 to assist other scientific publications. A grant was made to the Royal College of Physicians to cover the expected cost of producing a new edition of the 1928 Harvey film, by the use of colour photography, synchronized sound-track, animated diagrams and other appropriate improvements of cinematographic technique.

English Rural Life

THE Report of the Museum of English Rural Life for 1958 (University of Reading. Museum of English Rural Life—Report 1958. Pp. 24. Reading: The University, 1959. 1*s*.) is far from formal, for it includes, in fact is mainly devoted to, a summary of the principles of display in a museum. This part is contributed by Miss Margaret Fuller and Mr. C. A. Jewell and is of interest and value to all museum curators especially those who deal with the difficult problem of exhibiting folk-life material. In this report the policy of the Museum in relation to other regional museums is more clearly defined than it has been in the past and it is noted that it states its major task to be the formation of a national archive of information on all aspects of country life. It is hoped that in the future a considerable proportion of the objects in the Museum will be available to supplement other collections or to form the nucleus of new folk sections.

Genetical Effects of Population Subdivision

P. A. P. MORAN has advanced a theory relating to some genetical effects of population subdivision (*Australian J. Biol. Sci.*, 12, 2, 109 (1959)). The genetical effects of the subdivision of a population into partially isolated subgroups are considered in two particular cases. In the first a probability model is studied in which the subpopulations are of finite size with migration between them. In the absence of selection, the asymptotic rate of progress to homozygosity is shown to be very little affected by the subdivision. In the second case a deterministic model is studied in which there are two subpopulations in which selective forces are equal and opposite. A stable dimorphism is then shown to exist if there is any small amount of intermigration.

Fine Structure in Cells

G. Setterfield, H. Stern and F. B. Johnston have given an account of the fine structure in cells of pea and wheat embryos, based on observations using phase-contrast and electron microscopes (*Canadian Journal of Botany*, 37, 65 (1959)). The aim was to provide a basis for relating biochemical data on isolated cell fractions with the cytological structure *in situ*. Pertinent observations include the following:

The nuclei of all cells were similar, showing nuclear membranes, chromosomes, and prominent nucleoli. The cytoplasm contained highly developed structure which presumably reflected the incipient growth condition of the cells. Several cytoplasmic components were common to both embryos : small dense granules, endoplasmic reticulum, mitochondria, proplastids, amyloplasts, irregular bodies, plasma membranes, and plasmodesmata. The small dense granules, presumably ribonucleoprotein particles, occurred profusely, both free and in association with extensively developed endoplasmic reticulum. These particles are probably responsible for the microsomal fractions obtainable from embryos and seedlings. The mitochondria were usually relatively small (0·25–0·5μ diameter) although groups of very long (5μ) ones were occasionally found. Bodies resembling mitochondria in size and shape, but lacking cristae, were present and represent either immature mitochondria or proplastids. Reserve material occurred as starch in structurally complex amyloplasts and possibly as protein in the irregular bodies. In addition to these structures cells of the wheat embryos remote from the meristems contained prominent cytoplasmic bodies classified as 'dense' and 'thick-walled'. The dense bodies probably represent stored lipids while the significance of the thick-walled bodies, which showed a variety of forms, is unknown.

Rafflesia in Sumatra

Among the genera of plants which might well be described as wonderful, if not odd, *Rafflesia* must surely be accorded a leading place. Some thirteen species were recorded by Koorders in 1918 for the whole of the Malaysian region ; but it now appears that some of this investigator's views may require revision. W. Meijer (*Ann. Bogorienses*, **3**, 1, 33 (1958)) has now added further information on *Rafflesia arnoldi* as observed by himself and colleagues in West Sumatra. From an examination of the literature and the material preserved in the Herbarium Bogoriense, as well as from his own observations, he has concluded that the *Rafflesia* species in question is identical with the original *R. arnoldi* of Robert Brown (1822) and that it occurs in both Central and South Sumatra. Its taxonomic position is discussed, and the author points out that *R. tuan-mudae* Becc. from Borneo is very closely related to, and may even be conspecific with, *R. arnoldi* R. Br. ; and that the key given in Koorders's monograph is incorrect as to the distinction between these two plants. Some information concerning other *Rafflesia* species occurring on Sumatra is also given. Observations on the growth-rate, mortality of the buds, and the possible mode of distribution of the seeds are recorded. It is now estimated that the entire cycle from seed to seed takes approximately $4\frac{1}{2}$–5 yr.

Soil Basidiomycetes

J. H. Warcup has contributed the results of an investigation on the isolation of basidiomycetes from the soil (*Trans. Brit. Myc. Soc.*, **42**, 1, 45 (1959)). Whereas extensive series of dilution and soil plates from wheat-field and pasture soils failed to reveal these fungi, they were isolated from roots, and from hyphae, rhizomorphs, and sclerotia picked out from soil. Over a three-year period, no basidiomycete fructifications were found in the wheat-field although isolations from soil and roots showed that the field had an abundant and varied population of basidiomycetes. While fructifications were obtained from the pasture, the species thus seen fruiting were different from those isolated from soil and roots, indicating that the population was more varied than the fructifications alone would suggest. Some of the basidiomycetes were induced to form fructifications in culture.

Histological Localization of Peroxidase

D. S. Van Fleet (*Canadian J. Bot.*, **37**, 3, 449 (1959)) has observed that peroxidase is detectable in all tissues but is most reactive in the basophilic cells of the histogens. Oxidation of applied phenols and aminophenols by peroxidase produces quinones and quinonediimines that are adsorbed by nucleic acids and other basophilic substances in the formative centres of primordia. Localized reactions for peroxidase occur in the axils of leaf primordia prior to bud formation and on the surface of apical meristems in a spiral pattern marking the points for the future development of leaf primordia. Peroxidase is detectable in advance of or accompanying cell division and declines after the division phase ; decline of peroxidase at the end of the division phase is related to the increase of phenols, naphthols and phenolases. Peroxidase declines in all tissues with the exception of the phloem ; a continuous peroxidase system in the phloem connects primordia with adult tissue. The hypothesis is offered that the cellular units of the phloem peroxidase constitute a continuous system between primordia and adult tissue and are functional in catalysing the reduction of hydrogen acceptors essential to cell division and the initiation of primordia.

Oxidation of Krebs Cycle Acids by Apple Tissue

M. D. Hatch, J. A. Pearson, A. Millerd and R. N. Robertson, in a study of the oxidation of Krebs cycle acids by tissue slices and cytoplasmic particles from apple fruit (*Australian J. Biol. Sci.*, **12**, 2, 167 (1959)), point out that it has hitherto been difficult to demonstrate the Krebs cycle in either cytoplasmic particles or tissue slices obtained from apple fruit. In the present investigation, evidence was obtained for the operation of the classical Krebs cycle–cytochrome oxidase respiratory system in cut tissue and mitochondria from Granny Smith apples. The respiration of cut tissue increased when either citrate, α-ketoglutarate, succinate, malate, fumarate, or pyruvate were added. Both the endogenous and acid-stimulated respiration were inhibited by malonate, cyanide, and azide. The rapid oxidation of Krebs cycle acids by cytoplasmic particles from apple flesh was also demonstrated. These particles showed cytochrome oxidase activity and contained a succinoxidase system dependent on cytochrome *c*.

Radiation in Industry

Arthur D. Little, Inc., undertook during 1958 a study of the anticipated need for high-level radiation sources and their potential uses in industry, on behalf of the CEM group of companies (Emerson Radio and Phonographic Corporation, General Airline and Film Corporation, and Revere Copper and Brass, Inc.) and the General Electric Company's Hanford Atomic Products Operation. A summarized version of the firm's report was given by S. E. Eaton and M. Michaelis at the seventh annual conference of Atomic Energy in Industry (Radiation : a Tool for Industry. Pp. i+28. Cambridge, Mass. : Arthur D. Little, Inc., 1959), held by the National Industrial Conference Board, Inc., at Cleveland, Ohio, during

April 8–10, 1959. The study was restricted to a survey and analysis of the available technological data and consisted of an examination of some 2,500 articles published during the past ten years and a series of some 330 interviews with leading workers in the field. The pattern of current industrial activity in the applications of penetrating high-intensity ionizing radiations; present-day radiation costs; and radiation applications to chemicals and petroleum, to polymers, to pharmaceutical products, medical supplies and food, to power sources, and to miscellaneous substances such as semiconductors, are separately discussed. Much basic work has been done on relatively simple systems, but more research on basic reaction mechanisms and more and better research equipment are required. There is a considerable lack of knowledge both among industrial scientists and by the general public on the subject of radiation, its benefits, and the safeguards against its possible hazards. Future long-term research on the effect of radiation on systems held at very low temperatures and very high pressures; the development of new techniques in solid catalyst activation; and the study of the usefulness of low-energy radiation in the 1–1,000 eV. range, are some of the recommendations in the report. It is emphasized that work up to date has been largely empirical, that possible unique features of radiation applications have not yet been fully explored, and that even radiation engineering is relatively undeveloped and radiation economics uncertain.

Nobelium Research

In 1957 P. R. Fields and others reported the production at Stockholm of an isotope of element 102 in experiments in which curium targets were bombarded with cyclotron-accelerated $^{13}C^{4+}$ ions (*Nature*, **180**, 1010 and 1012, 1957). Two other groups have since reported experiments on the production of element 102. At Berkeley, A. Ghiorso *et al.* bombarded curium with carbon-12 and carbon-13 ions accelerated in *Hilac*, but did not observe the 102-isotope reported by Fields *et al.* They detected and identified the presence of the isotope $^{254}102$ which has a half-life of three seconds. In Moscow, G. N. Flerov and co-workers, by bombarding plutonium-241 with $^{16}O^{6+}$ ions, observed a short-lived product emitting long-range alpha particles with an energy of $8{\cdot}8 \pm 0{\cdot}5$ MeV. which they ascribe to an isotope of element 102. Because of the negative results at Berkeley, Fields and his co-workers have recently made a thorough re-examination of their experimental data, and their comments and discussion on the Berkeley and Stockholm experiments are given in a paper in the *Arkiv för Fysik*, **15**, 225 (1959). They conclude that though their earlier mass assignment made in 1957 seems now less certain, nevertheless their re-examination has not led to any new conclusions regarding the interpretation of their results. It is felt that judgment on the discovery of the element 102 should be reserved until additional experimental studies, including the properties of neighbouring nuclides, have been carried out.

Borden Award of the Nutrition Society of Canada

The Nutrition Society of Canada has announced that the Borden award of the Nutrition Society of Canada will be given annually in recognition of outstanding research work done by one of its members. The first award will be made in June 1960. The recipient of this award, which has been presented by the Borden Company Foundation, Inc., must be under the age of forty years and must have published the meritorious work within the preceding three years. It is hoped that this award will further encourage research activities by younger members of the Society.

Lady Tata Memorial Trust

The Trustees of the Lady Tata Memorial Trust, on the recommendation of the (European) Scientific Advisory Committee, have made the following awards for research on leukæmia and allied diseases in the academic year beginning October 1, 1959. *Grants for Research Expenses:* Dr. M. Bessis (France), Centre National de Transfusion Sanguine, Paris; Dr. B. M. Braganca (India), Indian Cancer Research Centre, Bombay; Prof. G. Klein (Sweden), Karolinska Institute, Stockholm; Dr. J. Pontén (Sweden), Pathology Institute, Uppsala; Dr. M. Simonsen (Denmark), Institute of Pathological Anatomy, Copenhagen; Dr. A. E. Stuart (Scotland), Department of Pathology, University of Edinburgh; *Scholarships:* Dr. J. Hastrup (Denmark), Institute of General Pathology, Aarhus; Dr. E. Kelemen (Hungary), Postgraduate School of Medicine, Budapest; Dr. P. A. Pillai (India), Centre de Microscopie Electronique, Lausanne, Switzerland.

Paul Instrument Fund Awards

Awards by the Paul Instrument Fund Committee of the Royal Society have been made as follows: £1,000 to Dr. H. B. Barlow, assistant director of research, Department of Physiology, and Mr. P. E. K. Donaldson, technical officer, Physiological Laboratory, Cambridge, for the development (*a*) of a device for automatically improving coding of messages, and (*b*) of a diffused storage sequence engine, the object being to advance knowledge of the operation of comparatively simple assemblies of nerve cells by making instruments which perform the same task as such assemblies; £600, in supplement of a previous grant, to Dr. E. T. Hall, senior research officer at the Research Laboratory for Archæology and the History of Art, Oxford, for improvements to an apparatus with which magnetic measurements may be made with the view of dating archæological material; £2,000 to Dr. H. Motz, reader in engineering science, University of Oxford (in association with Prof. G. B. Walker, professor of electrical engineering, Essex College, Assumption University, Windsor, Ontario), for the construction of a linear accelerator working at 1·6 cm. (*J*-band); £5,500 to Prof. R. O. Redman, professor of astrophysics in the University of Cambridge, for the construction and testing of a thin astronomical mirror of plate glass and of a new type of support system; £5,900 to Dr. P. M. B. Walker, Royal Society Research Fellow, Department of Zoology, Ashworth Laboratory, University of Edinburgh, for the construction of a new microspectrophotometer that will integrate over a defined but irregular area which can be altered quickly and easily.

Grant for the Massachusetts Institute of Technology

Dr. Julius A. Stratton, president of the Massachusetts Institute of Technology, announced recently that the Institute had received a gift of

2,527,500 dollars (about £900,000) from Mr. and Mrs. C. H. Green of Dallas, Texas. This represents the March 31 market value of 30,000 shares of stock of Texas Instruments Inc., in which form the gift was made. The money will be used to construct a multi-story building on the Institute site, and will be a centre for the study of Earth sciences. Laboratories for research work in geophysics, meteorology, oceanography and related fields will form an important part of the new building.

University News: London

Dr. P. Grootenhuis, lecturer at the Imperial College of Science and Technology, has been appointed to the University readership in mechanical engineering tenable at that College. The title of reader in sociology in the University of London has been conferred on Mr. T. B. Bottomore, in respect of his post at the London School of Economics and Political Science. The title of professor emeritus in the University has been conferred on: Prof. R. J. S. McDowall on his retirement from the Halliburton chair of physiology at King's College; Prof. Margaret M. A. Murray on her retirement from the chair of physiology at Bedford College; Prof. J. H. Woodger on his retirement from the professorship of biology at the Middlesex Hospital Medical School; and Prof. H. J. Collins, on his retirement from the Chadwick chair of civil engineering at University College.

University College of Rhodesia and Nyasaland

Mr. W. Lloyd Jenkins has been appointed lecturer in the Department of Chemistry with responsibility for teaching agricultural chemistry. Previously he was a lecturer in agricultural chemistry in the University College of Wales, Aberystwyth.

The Night Sky in October

New moon occurs on Oct. 2d. 12h. 31m. U.T., full moon on Oct. 16d. 15h. 58m., and new moon on Oct. 31d. 22h. 41m. The following conjunctions with the Moon take place: Oct. 6d. 00h., Jupiter 4° S.; Oct. 8d. 05h., Saturn 5° S.; Oct. 28d. 14h., Venus 0·9° N. In addition to these conjunctions with the Moon, Venus is in conjunction with Regulus on Oct. 1d. 08h., Venus being 5·7° S., and Mercury with Spica on Oct. 4d. 09h., Mercury being 2·1° N. There will be a total eclipse of the Sun on October 2, visible as a partial eclipse at Greenwich. The path of totality begins at sunrise on the eastern seaboard of the United States, crosses the North Atlantic, Canary Islands and North Africa, ending in the western Indian Ocean at sunset. The partial eclipse which will be seen at Greenwich begins at 11h. 01m., reaches its greatest magnitude of 0·33 at 11h. 58m. and ends at 12h. 56m. The eclipse belongs to a series which began in 1599. Mercury is too close to the Sun for observation. Venus is a morning star, rising at 2h. 55m., 2h. 30m. and 2h. 35m. on October 1, 15 and 31, respectively. Its stellar magnitude is approximately −4·3; greatest brilliancy is reached on October 8. Its distance increases during the month from 36 to 55 million miles and the visible portion of the apparent disk increases from 0·211 to 0·443. Mars is too close to the Sun for observation, conjunction being on October 29. Jupiter is also too close to the Sun for observation. Saturn sets at 21h. 20m., 20h. 25m. and 19h. 30m. on October 1, 15 and 31, respectively. Its stellar magnitude is +0·8; it remains in Sagittarius. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: Oct. 10d. 20h. 13·4m., τ Cap. m. (*D*); Oct. 17d. 20h. 04·4m., ξ Ari. (*R*); Oct. 20d. 23h. 35·1m., 318 B. Tau. (*R*); Oct. 21d. 23h. 38·6m., 130 Tau. (*R*); Oct. 28d. 4h. 22·0m., 58 Leo. (*R*). *D* and *R* refer to disappearance and reappearance, respectively. The Giacobinids are active on October 9 and the Orionids during the third week of the month; conditions for both are unfavourable.

Announcements

Lord Netherthorpe, president of the National Farmers' Union, and Prof. F. W. Rogers Brambell, professor of zoology in the University College of North Wales, Bangor, have been appointed to fill vacancies in the membership of the Agricultural Research Council caused by the retirement of Sir Solly Zuckerman and Mr. Frank Rayns.

Dr. A. G. Ogston has resigned from the chairmanship of the Editorial Board of the *Biochemical Journal* and the Committee of the Biochemical Society has appointed Dr. W. V. Thorpe as his successor. Correspondence and communications should still be sent to the Secretary to the Editorial Board, Lister Institute of Preventive Medicine, Chelsea Bridge Road, London, S.W.1.

The following officers of the Association of Consulting Scientists have been elected: *Chairman*, Dr. J. G. Davis; Hon. Treasurer, Dr. G. W. Ferguson; Hon. Secretary, Mr. W. H. Stevens, 15 Hawthorne Road, Bromley, Kent.

A meeting will be held on October 31 at the University of Nottingham with the object of forming a Society for Forensic Science. Further information can be obtained from Mr. S. S. Kind, 18 Hall Lane, Harrogate, Yorkshire.

The eighth German Plastics Convention will take the form of an International Symposium on the Ageing of Plastics; it will be held during October 19–21 at Düsseldorf, Germany. Further information can be obtained from the Arbeitsgemeinschaft Deutsche Kunststoff-Industrie, Frankfurt (Main), Karlstr. 21.

The German Society for Electronmicroscopy is holding a conference on various aspects of electronmicroscopy at the Departments of Pathology and Anatomy, Albert-Ludwigs-University, Freiberg im Breisgau, Germany, during October 18–21. Further information can be obtained from Tagung der Deutschen Gesellschaft für Elektronenmikroskopie e.V. Pathologisches Institut der Universität, Freiburg, Albertstr. 19.

The City of London College, in collaboration with the Plastics Institute, has arranged a series of eight lectures on plastics which will be given on successive Mondays at the College, commencing on October 5. Further information can be obtained from Mr. A. Fawthrop, head of the Department of Shipping and Commercial Products, City of London College, London, E.C.2.

Erratum. The author of the communication "Appearance of Granules in the Cytoplasm of Tumour-cell Cultures in Contact with Lysozyme" in *Nature* of July 18, p. 202, is Mrs. Dirce Babudieri Callerio, and not Prof. Carlo Callerio as printed.

FLUCTUATION PHENOMENA AND STOCHASTIC PROCESSES

THE theory of probability developed as a branch of pure mathematics. Its applications to physics have now become so widespread that there is scarcely a branch to which it does not contribute significantly. During the nineteenth century the establishment of the statistical nature of the second law of thermodynamics, the resolution of the irreversibility paradox, and the development of the powerful technique of statistical mechanics were all the result of applying statistical methods to an atomic population. In the twentieth century the wave-particle paradox was solved by rooting atomic physics in the theory of probability. At a less fundamental level, Brownian movement, diffusion and radio noise are physical phenomena the character of which is essentially stochastic; and radio-wave propagation, sea waves, nuclear reactors and polymer physics are examples of fields in which stochastic problems have recently attracted considerable attention.

The apparatus of the mathematician has been accepted with gratitude by the physicist: generating functions and characteristic functions for manipulating probability distributions; generalized Fourier analysis introducing autocorrelation functions, and leading to the Wiener–Khintchine theorem for fluctuation phenomena stationary in time. In return the physicist has continually thrown up a variety of novel problems to challenge the ingenuity of the mathematician and maintain his interest.

The two-day conference of the Physical Society on "Fluctuation Phenomena and Stochastic Processes", held at Birkbeck College on March 19 and 20, attracted research workers in many different fields. Altogether, twenty-nine papers were presented; most of the participants were British, although contributions also came from the United States, Canada and Norway.

In his opening remarks of welcome, Prof. J. D. Bernal (Birkbeck College, London) pointed out that physics had learnt to deal adequately with the completely regular, and the completely random; it was the partially regular which still awaited treatment. The nature of the liquid state, and biophysical problems connected with the structure of large molecules, were important examples of this.

In the opening paper, Prof. M. S. Bartlett (University of Manchester) reviewed the various types of statistical fluctuations which occurred in physics, and attempted to classify them in order of relative size. In spite of the existence of occasional abnormal fluctuations, macroscopic averages in classical statistical mechanics had a 'stability' resulting from the large number of component systems involved. The measurement of time and space averages for phenomena such as turbulence and random surface waves, on the other hand, made use of the ergodic properties of some stationary processes. A fairly general 'weighted sum' type of process occurring in noise and Brownian motion theory was defined, together with the conditions for statistical 'stability'. Finally, there was the class of possibly exponentially increasing and unstable multiplicative (branching) processes such as nuclear cascades.

Dr. R. Furth (Birkbeck College) gave a comprehensive paper entitled "Fluctuations of Macroscopic Parameters". Macroscopic parameters ξ_i were operationally defined in finite regions Δs, of space and finite intervals Δt, of time of such magnitude that irregular fluctuations could be observed superimposed over the regular quasi-continuous functions $\xi_i(r,t)$. The theory of these fluctuations was mainly concerned with the determination of the second moments of the temporal fluctuations of the parameters ξ_i in a fixed Δs, and of the spatial fluctuations in one and the same Δt. It was a characteristic feature of the theory that these moments could be expressed in terms of the macroscopic functions, $\xi_i(r,t)$, and that only some very general statistical properties of the random molecular processes responsible for the fluctuations needed to be known.

In the temporal problem the correlation functions of the type $c_s(\tau) = [\overline{\xi_i(\tau)\xi_j(t+\tau)}]_s/(\overline{\xi_i\xi_j})_s$ could be calculated by making use of a generalized 'Langevin equation'; in the limiting case of $\tau = 0$ the second moments $(\overline{\xi_i\xi_j})_s$ might be obtained under conditions of statistical stationarity from statistical mechanics. This latter procedure could be applied to the problem of fluctuations of strain and stress in crystalline solids.

In the problem of spatial fluctuations the same method of statistical mechanics could be used for evaluating the spatial correlation products $[\overline{\xi_i(x)\xi_j(x+\zeta)}]_t$ of two parameters in two regions $(\Delta s)_1$ and $(\Delta s)_2$ in a homogeneous medium, separated by a distance ζ under conditions of 'quasi-stationarity', that is, when in spite of the finite speed of propagation of the interaction processes the values $\xi(x)$ and $\xi_j(x+\zeta)$ could be assumed to be simultaneous to a sufficient degree of approximation. This method could be used to obtain formulæ for the fluctuations of electric charge and potential in a discontinuous system of conductors; and had been applied by E. Morris to the problem of fluctuations of surface charge density on the surface of a single continuous conductor, and the fluctuations of potential on and outside its surface.

Finally, the general problem of spatial fluctuations could be reduced to that of temporal fluctuations in such cases where the relevant Langevin equation had the character of a wave equation. This method was used by M. N. Moore for the solution of the problem of spatial fluctuations of strain and stress in crystalline solids.

Several papers dealt with the mathematical properties of stochastic functions, and with their application to the analysis of experimental data. Mr. D. G. Brennan (Massachusetts Institute of Technology, Lincoln Laboratory) in a paper entitled "A New Approach to Certain Types of Random Functions" developed *ab initio* a theory of a class of stochastic processes which he hoped would have application to certain types of physical problem. Mr. M. B. Priestley (University of Manchester) considered the problem of detecting a signal containing several harmonic components in the presence of background noise. When the noise had a uniform spectrum the appropriate quantity for picking out the harmonic terms was the periodogram. But when the spectrum of the noise was non-uniform this could no longer be used, and he proposed a method of analysis based on the

tail of the auto-correlation function; he also showed how a significance test could be constructed.

Mr. B. Landmark (Norwegian Defence Research Establishment) dealt with the provision of a stringent test for the Gaussian character of a given noise signal. An amplitude test was usually insufficient, and he suggested using the simultaneous variations in amplitude and phase. This had been applied experimentally to the scattering from ionospheric clouds[1], and the results were in good agreement with those to be expected for Gaussian noise.

Dr. L. Mandel (Imperial College of Science and Technology, London) gave an interesting example of a problem in which the approach of the quantum theory produced a substantial simplification. The distribution of the integral, E_T, over a time interval T of the square of random noise was quite complicated, and some of its properties had been deduced by Rice[2]. If we interpreted the noise as arising from an electromagnetic wave, E_T was proportional to the energy contained in a length cT of the wave train. Bose–Einstein statistics could be applied to the photons in this region, and the resulting probability distribution could be determined more readily.

The statistics of radioactive decay was the subject of a communication by Mr. A. C. Hughes. He was concerned with testing fluctuation theory for short-lived substances, that is, those with half-lives short compared with the time of observation. Experiments had been performed with an isotope of rhodium (half-life 44 sec.), and two isotopes of silver (half-lives 24 sec. and 2·3 min.); the agreement with theory was good.

Dr. M. N. Moore (Birkbeck College) spoke on the "Stochastic Kinetics of Nuclear Reactors". It could be shown that the square of the modulus of the reactor transfer function was proportional to the Fourier transform of the auto-correlation function for power noise in the reactor. Since the power noise represented the response to the minimum power input signal, measurements of transfer functions based upon reactor noise were of all possible measurements least subject to non-linear distortion. By performing the experiment at various power-levels and temperatures, it was possible to measure both power and temperature coefficients[3].

Some examples were given of new problems in probability which had been suggested by physical phenomena. Prof. C. Domb (King's College, London) said that if one wished to understand what was happening in a regular solution, one must study its fluctuation properties, or the distribution of clusters of different sizes and shapes as a function of temperature. Even for a purely random mixture this was very difficult, although one could readily establish a difference in behaviour in one, two or three dimensions. Thus for a 50 : 50 mixture if one considered clusters of up to 5 atoms, 88 per cent of the total number were accounted for in one dimension, 17 per cent in two dimensions and only 2 per cent in three dimensions. A critical probability entered in these problems in the same manner as those studied by Hammersley[4].

Dr. M. E. Fisher (King's College, London) discussed the shapes and sizes of polymer and polyelectrolyte molecules which seriously affected properties like viscosity. We should be greatly assisted in this field by a knowledge of the properties of non-intersecting random walks on lattices. These walks were non-Markovian and their behaviour probably differed essentially from Markovian walks. The only property which had been rigorously established[5] was that C_n, the total number of walks of n steps, was asymptotically of order μ^n. Some conjectures on the value of μ for a quadratic lattice had been rigorously disproved[6]. The subject suffered seriously from a lack of theorems of the 'central limit' kind. Dr. M. F. Sykes (King's College, London) dealt with methods for the practical determination of parameters in self-avoiding walks. Monte-Carlo methods had been used extensively by Wall and his collaborators[7], but Sykes and his colleagues had preferred to determine the properties exactly for finite values of n, rather than to attempt asymptotic extrapolation. When n was larger than about 10, irregular variations were small, and one could put forward the results with confidence. He estimated that for a quadratic lattice $c_n \sim n^{1/3}\,\mu^n$, where $\mu \simeq 2{\cdot}640$ (with a probable error $< \frac{1}{4}$ per cent). Also there was strong evidence that if p_n is the number of simple closed polygon walks of n steps, then $p_n{}^{1/n} \to \mu$.

Mr. J. M. Hammersley (Atomic Energy Research Establishment, Harwell) spoke on "Percolation Processes"[4]. These differed from diffusion processes in that the random mechanism was in the medium instead of the fluid. Practical examples of percolation processes were molecules penetrating a porous solid, or disease infecting a community. The processes could be studied in crystals or mazes, and the mathematics was more difficult than that of diffusion processes. It was possible to show rigorously that critical probabilities existed for crystals below which, for example, a fluid starting in one part of the medium would not spread to infinity. Upper and lower limits had been established theoretically for these probabilities, and Monte-Carlo methods had been successfully used to estimate them.

It was not surprising to find several papers devoted to the random walk problem and Brownian movement. Dr. P. H. Roberts (King's College, Newcastle) spoke on the "Random Walk on a Sphere". He was concerned with the geological problem of the path of the Pole as indicated by rocks. Other work in this field had assumed a lattice model, and a planar distribution[8a]. With the mathematical help of H. D. Ursell, he had used the correct distribution for a sphere, which, incidentally, differed appreciably from the distribution given by R. A. Fisher[8b].

The effect of persistence on a random walk was discussed by Mr. A. J. Allnut. In problems such as multiple scattering in foils the assumption that all directions of scatter were equally probable after collision was invalid; it was necessary to take into account persistence in the initial direction, and formulæ for the mean and mean square deviation could readily be derived. Mr. J. C. Barton (Northern Polytechnic, London) described an experimental method of simulating a one-dimensional random walk. This was a problem in which an analogue computer could be of value and could provide information on first passage times for a random walk with persistence[9]. (In the discussion Prof. Bartlett pointed out that theoretical formulæ for first passage times were available for all Markoff processes.)

Dr. A. R. Stokes (King's College, London) in his paper on "Light Scattering by Semi-stiff Chain Molecules" referred to a different application of an analogous problem. The distribution of the end-to-end distance of a flexible chain was Gaussian; stiffness in the chain restricted the freedom of the angle between successive links, and modified this distribution, thus influencing the light-scattering

properties. The modified distribution had been calculated by Daniels[10], but he had found a simpler approach by using the Fourier transform of the end-to-end distance. The results could be expressed in a form suitable for practical calculation.

The Brownian movement of non-linear systems was discussed by Dr. D. K. C. MacDonald (National Research Council, Ottawa). Many problems in this field still awaited solution. Some results of his own approach[11] had been substantiated by R. O. Davies[12], although there was some disagreement with van Kampen[13], who maintained that the distribution of fluctuations was Gaussian even for non-linear systems. Dr. MacDonald mentioned that he had corresponded with Einstein, who agreed that the statement in his early work on the Gaussian nature of the distribution needed reconsideration.

Dr. A. Suddaby (Sir John Cass College, London) discussed the relation between the microscopic theories of transport processes developed by Kirkwood, and the macroscopic theory of Brownian movement. In the course of his development, Kirkwood introduced a friction constant β which was an integral up to time τ of the correlation of the total force on the particle at different times. The analogous constant in Brownian movement theory was determined by the correlation of the fluctuating force in the Langevin equation. These two values could be shown to agree provided $\beta\tau \ll 1$.

Dr. E. R. Wooding (University of Sheffield) presented a paper on "Recombination in a Plasma as a Stochastic Process". The rate at which ions of opposite charge diffused together was obtained by applying Kramer's method to solve Smoluchowski's equation for diffusion in a field of force. Charge transfer was assumed to occur after the ions approached to within a distance where they could enter a bounded orbit. An ion or atom in the vicinity of an orbit influenced the recombination coefficient. The resulting function was dependent on the degree of ionization, but was similar to that obtained by Thomson[14] at low pressures, and changed to Jaffe's relationship[15] at high pressures if the ionization was low.

Dr. G. Wyllie (University of Glasgow) discussed the Brownian motion of spin systems. There were two sources of interest in this problem, its neatness as a model for irreversible processes in quantum mechanics, and the experimental interest in nuclear magnetic resonance experiments. If one focused on individual spins, relaxation times were of the order of milliseconds, whereas for the whole spin system they ranged up to hours. By manipulating electromagnetic fields the spin system could be thrown into conditions far from the Boltzmann distribution. The fluctuating interaction between spins revealed itself in the shape of the magnetic resonance absorption line.

A group of papers was concerned with stochastic problems arising in radio physics. Mr. J. A. Ratcliffe (University of Cambridge) gave an introductory talk, and discussed some problems associated with the Fresnel diffraction patterns formed by an assembly of random irregular diffracting screens. It was well known that, if the correlation function $\rho_f(\xi)$ of the complex amplitude $f(x)$ over a one-dimensional diffracting screen was defined as $< f(x)f^*(x+\xi) >_{\text{screen}}$ and if $g(x)$ was the complex amplitude in the diffraction pattern over any plane parallel to the screen, then with certain reservations $\rho_f(\xi)$ was equal to $\rho_g(\xi)$. If the screen was statistically stationary over x and if the correlation function $r_f(\xi)$ was defined as $r_f(\xi) = < f(x_1)f^*(x_1+\xi) >$ evaluated at two fixed points x_1 and $(x_1+\xi)$, then it was also true that $r_g(\xi) = r_f(\xi) = \rho_f(\xi)$. If, however, the screen was not statistically stationary the last relation was not necessarily true.

Mr. Ratcliffe considered particularly the non-stationary case when the screen $f(x)$ could be described as an assembly of infinitely long random screens placed, in succession, in front of an aperture of finite width. He suggested that this simple example represented approximately the problems of the diffraction of (*a*) radio waves radiated from a radio star with a sharp boundary, (*b*) light waves radiated from a source of light placed behind a slit, or (*c*) radio waves reflected from an irregular meteor trail of limited length. He stated that, if the limiting aperture subtended less than the first Fresnel zone at the observing plane, then $r_g(\xi)$ was determined, not by the fine structure in the screen, but by the aperture bounding it. If, however, the aperture subtended a large number of Fresnel zones then $r_g(\xi) = r_f(\xi)$ and was determined by the fine structure in the screen.

Mr. S. A. Bowhill (Pennsylvania State University) discussed the scattering of electromagnetic waves from a continuous medium containing three-dimensional random inhomogeneities of refractive index. He had derived the form of the emerging angular power spectrum when the scales of the inhomogeneities were different in the three space directions. Contrary to previous results[16], he had found that the medium could not be analysed as a series of superposed thin phase screens, spaced in the propagation direction, and with independent phase profiles.

Mr. M. L. V. Pitteway (University of Cambridge) was concerned with reflexion from an irregular medium. Before proceeding to a three-dimensional solution for irregularities he thought one should obtain a solution for a horizontally stratified ionosphere[17] and treat the irregularities as a small perturbation. The power spectrum of the scattered wave could then be expressed as an integral in terms of the stratified solution. Dr. B. H. Briggs (University of Cambridge) dealt with the experimental problem of specifying the pattern on the ground (including time changes and movements) formed by reflexion from, or transmission through, an irregular ionosphere. He defined parameters which could be used to specify this pattern, and which could be deduced from observations at a few points on the ground[18]. As an example, he considered the application to radio star scintillations. Mr. R. P. Mercier (University of Cambridge) discussed theoretical aspects of radio-wave fading. A scalar wave with random variations of amplitude and phase across the wave front was taken as a simple model. It was assumed that the in-phase and quadrature components of the fluctuating part of the field were normally distributed, and a parameter was introduced to specify the intrinsic correlation of the fading. Various properties of this parameter could be derived, and used to interpret fading from the ionosphere.

"Coherence Properties of Partially Polarized Light" was the subject of the paper by Dr. E. Wolf (University of Manchester). Observing that the usual definition of Stokes parameters of a quasi-monochromatic plane electric wave was not unique, an experiment was analysed which led to a unique

coherency matrix and to a unique set of Stokes parameters. The degree of polarization of such a wave was also equal to the maximum value of the degree of coherence which existed between the components of electric vibrations in orthogonal directions in the wave front. This suggested a new method of measurement of the degree of polarization, based on interference experiments.

Prof. E. G. Richardson (King's College, Newcastle) referred to experiments on the propagation of sound waves in a fluid having random variations in either density or momentum, whereby the amplitude and relative phase of the signal picked up after transmission through the medium fluctuated in time. The former type occurred near the critical point of a fluid or of a mixture of liquids, the latter in the atmosphere or in the wake of an obstacle or, again, in a boundary layer. Analyses of such measurements were presented. In the case of the liquid mixture a correlation was sought between the pattern of the scattered radiation and the mean size of the clusters which formed at the critical point. As an example of the second type, frequency spectra of the modulations of the sound signal transmitted athwart the wake of a cylinder involved the discerning of peaks in the spectrum against the background of fluctuation 'noise' in the general flow.

Dr. M. S. Longuet-Higgins (National Institute of Oceanography) discussed "Sea-Waves as a Stochastic Process". He showed a typical record of pressure at a fixed point on the sea bed which agreed closely with a Gaussian distribution. Non-Gaussian features usually appeared when the waves were steep and near the point of breaking, or in shallow water. To describe the sea surface a random process two spatial dimensions and one of time were needed; the practical problem for wave forecasting was to relate this to winds and other relevant factors. Dr. Longuet-Higgins also listed a number of properties of a Gaussian surface which might be of use in determining the spectrum; these included wave slopes[19], 'specular points' and 'twinkles'[20].

The final paper was given by Prof. E. W. Montroll (University of Maryland) on a stochastic treatment of traffic flow. Experimental data indicated that the acceleration of a car in a line of traffic at time t was proportional to the velocity difference between itself and its neighbour at time $(t - \Delta)$, where $\Delta \sim 1{\cdot}5$ sec. and the proportionality constant[21] was 0·37 sec.$^{-1}$. Theoretical investigation showed that the motion became unstable when the product of lag time and proportionality constant exceeded 1/2. Thus the experimental data showed that driving was usually on the verge of instability. 'Acceleration noise' was put forward as a parameter which would characterize the driver – car – road complex under various conditions[22]. Reasonable agreement was obtained with traffic flow measurements[23].

The conference was organized at the suggestion of Dr. Furth, who is to be highly commended on his initiative. The one hundred participants would undoubtedly wish to express their thanks to him, to Birkbeck College, and to the Physical Society for the excellent arrangements.

C. Domb

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BIOMECHANICS

On April 17 the Institution of Mechanical Engineers held a symposium on "Biomechanics" with the purpose of bringing medical men and engineers into closer contact.

Biomechanics, in its broadest sense, may be defined as the branch of science which applies the principles of mechanics and the techniques of engineering to the human body in the process of its repair, and in the field of man – machine relationship, where man is the essential link in operating these machines.

The symposium was opened by the President of the Institution and the papers and discussion were presented under the chairmanship of Prof. S. J. Davies. In the opening paper on the importance of biomechanics as a service to man, illustrated by a discussion of problems in metallic osteosynthesis, J. M. Zarek, from King's College, London, gave a brief account of the nature of biomechanics as a new field of endeavour in which some of the engineering knowledge may be of direct use to the medical man. The man – machine relationship was only mentioned, as this aspect of biomechanics appears to be already well appreciated by the engineers and was not dealt with at the symposium in detail. After discussing the scope of biomechanics, the general history and current British activities in this field were reviewed. Problems of bone repair were considered at length and the work in the Civil Engineering Department at King's College, London, on the stress/bone formation relationship and the behaviour of metals in the human body were discussed.

In the second paper, R. I. Tanner, from the University of Manchester, presented a paper on some tests on 'Fluon' as a material for artificial animal joints in which results of artificial hip-joint friction and wear are given. They are based on the results obtained by means of simple pendulum apparatus which provides a reasonable approximation to the walking motion of a normal person.

A critical review of published work on the nature of lubrication in animal joints was given by John Charnley from the Department of Orthopædics at Manchester. Further, some of the experiments which have been accepted in support of the theory of hydrodynamic lubrication have been repeated by him to show that the lubrication of animal joints is almost certainly a boundary phenomenon. Charnley emphasized that the coefficient of friction of animal joints reaches a very low figure and surpasses in slipperiness any combination of sliding surfaces known to engineering.

A paper on the provision of workable substitutes for missing or defective limbs was presented by D. S. McKenzie and Brig. N. A. M. Swettenham, from the Limb Fitting Centre, Ministry of Health, Roehampton.

Limb fitting has been essentially a craft until quite recently, and many ideas current in the last century exist materially unchanged to-day. This situation is now changing as a great deal of research work on artificial limbs with emphasis on fundamental studies is in progress. Some of the problems here are very complex. The prosthesis has to replace a human component but it does not necessarily follow that its mechanical design should copy that of the part it replaces. Amputation often changes the pattern of muscular control and weight bearing. The paper also described some of the features governing the construction of artificial limbs. Each case has to be treated individually and *ad hoc* modifications have to be made to suit individual needs. In a research field of this nature it is difficult to prove that a proposed change has merit, and evaluation techniques still require much development. Some devices evoke general acceptance, but more often individual responses vary and the type of case for which the new idea is best suited must be discovered. Only users can supply the final answer, but they cannot give up unlimited time to experimentation. Objective testing is therefore necessary to eliminate obvious flaws and shorten user trials.

Following the presentation of the papers, a film entitled "Late Results of Four Massive Internal Prosthesis" was shown by A. C. Bingold and W. G. France. Here the authors gave an excellent picture of how, through the co-operation of surgeons with engineers, instead of amputation, limbs can be saved and restored to their normal use.

The success of the symposium, I think, was reflected in the very interesting discussion which followed and well exceeded the time limit allocated for this purpose.

The Institution was honoured by the presence of Sir Harry Platt, of the Royal College of Surgeons, who, in opening the discussion, stressed the importance of interdisciplinary work between the medical men and engineers. He said that the symposium had clearly demonstrated that some of the surgical techniques now in use are so complex that it is impossible for one profession only to solve the problems involved.

Dr. F. C. Harper, of the Building Research Station, showed a film and some results obtained in the course of studying the forces exerted by the human foot in walking, the emphasis there being on the wear resistance of floor surfacing materials.

Dr. J. D. Moreland and Mr. S. J. Thurlow, of the Road Research Laboratory, discussed their investigations into the problems connected with road crash injuries.

Mr. E. H. J. Smyth, an orthopædic surgeon from the Southampton and Isle of Wight Hospital Groups, presented in a very interesting manner his views on the functional significance of the formation of trabeculæ in the neck of the femur.

Finally, because of shortage of time, after a number of speakers discussed a variety of subjects of their own interest, the authors of the papers answered various points raised in the discussion very briefly.

In conclusion, the large attendance and the discussion were an indication that the Institution of Mechanical Engineers had organized a successful symposium which from the 'mixed' audience indicated the growing affinity between engineering and medicine in the process of alleviating human suffering.

The Institution of Mechanical Engineers will shortly publish the proceedings of the symposium, which will include the discussion and communications.

J. M. Zarek

INTERNATIONAL STARCH CONVENTION, 1959

THE ninth annual Starch Convention, which took place at the Cereal Research Station, Detmold, Germany, during April 21–23, was attended by 360 chemists from seventeen nations. The papers which were read to the meeting were divided into four sessions, on research and analysis, starch manufacture, starch fractions and derivatives and on industrial applications.

The opening address was delivered by T. J. Schoch (Argo, Illinois), whose theme was the application of modern methods of starch chemistry to characterizing its useful properties. Waxy sorghum starch, which is comprised wholly of amylopectin, can be given some of the characteristic properties of corn starch by cross-linking the polysaccharide chains with phosphate, epichlorhydrin or fatty acid groups. The amount of cross-linking agent required to achieve this result is only 1 part per 1,000 parts of starch. Thus waxy starches, which normally give rise to fluid pastes, are deprived of this property and become 'short'. Simultaneously their resistance to shear increases greatly. Another result is that such starches lose the property of gelatinizing in water at a precise temperature, and instead show a gradual increase in solubility with rising temperature. Cross-linking also results in a marked improvement of resistance to freeze-thaw cycles, which has important implications for the food industry.

Improved freeze–thaw characteristics show as a lower rate of sedimentation after freezing, and better gloss and transparency of the paste.

The new properties of amylopectin obtained by cross-linking can be explained by a greatly reduced rate of retrogradation and greater internal rigidity of the starch molecule. The technique of cross-linking can be extended to dextrines, which are used as re-moistening gums on envelope flaps and labels. The deterioration of such gums on ageing has been shown to be due to retrogradation of the dextrine in the presence of small amounts of water. By using the hydroxyethyl derivative of dextrines for gumming purposes, the ageing characteristics of flap gums can be largely avoided. Finally, Dr. Schoch explained how starch films, which have been laid down by slow evaporation of water, have a greatly increased resistance to water when compared to quickly dried films. This again can be shown to be due to retrogradation taking place during the slow drying of films.

Prof. M. Samec (Ljubljana, Yugoslavia) described how the bursting and tear strength of paper can be markedly improved by using a starch size which has been previously irradiated with cobalt-60. This process might become of great importance if the cost of the radioactive material would be reduced in the future.

The use of starch as sizing agent in the paper industry was described by J. Seaman (Slough, Bucks). A beater size should preferably be a potato starch soluble in cold water, of which 5 per cent w/w is added to the paper pulp. Such starches are manufactured by passing a slurry containing starch and borax over steam-heated drying rolls. The product when re-dissolved has *p*H 8·5 at 5 per cent concentration. For surface sizing it is advantageous to use an oxidized starch, which is manufactured by treating potato starch with sodium hypochlorite. The material has to be cooked with water before use to give a size having *p*H 7·5 at 15 per cent solid-content. For paper coating, white potato dextrine (1 part) is added to china clay (5–6 parts) and the mixture made up with water to a slurry having a solid content of 50 per cent.

When selecting dextrines for coating purposes, it is essential to choose one with a maximum rate of set back to enable the coating to set on the surface of the paper as rapidly as possible.

Prof. M. Mautner (Zagreb, Yugoslavia) described a new method for the continuous production of glucose by the acid hydrolysis of starch. The starch slurry is first treated with hydrochloric acid and is then passed into a conical chamber, which rotates very quickly about its long axis. The chamber is heated externally by steam and is provided with an inlet at the wide end and an outlet at its apex. Ungelatinized starch particles are forced by centrifugal force to the walls of the chamber, where they gelatinize instantly. In so doing their specific gravity is reduced and they are replaced by further ungelatinized granules. The chamber has a peripheral speed of 30 m./sec. and it can deal with 2½ tons of raw starch per hr. After leaving the chamber the starch paste is fed into a series of flat, box-like heat exchangers, where the final conversion of starch to glucose takes place. It is estimated that the total time required for conversion is only 18 min.

At the Convention a total of twenty-two papers was read and they will be reprinted in full in the journal *Die Stärke*.

The actual Convention was followed during April 24–25 by the first meeting of the International Standards Organization Technical Committee No. 93, which has been set up to establish international recommendations for analysis of starch, including its derivatives and by-products. There were 65 delegates present from Czechoslovakia, Denmark, Eire, Finland, France, Germany, Hungary, Italy, India, The Netherlands, Norway, Switzerland and the United Kingdom. The chair was taken by Prof. K. Heyns (Hamburg), the secretariat being held by the German Standards Association. The British side of the work is in the hands of the British Standards Institute Committee on Analysis and Testing of Starch Products ; ten members of this committee—representing manufacturers and users of starch and associated products, research interests and Government departments—were present. The work already done by the British Standards Institute Committee enabled the British delegation to give a strong lead at these inaugural discussions of the International Standards Organization and many of the United Kingdom proposals were adopted.

It was agreed that the scope of the new International Standards Organization committee should cover : terminology, methods of sampling, methods of analysis and examination of starch, its derivatives (including hydrolysis products and dextrines) and its by-products.

E. Dux

THE EDUCATION OF TECHNOLOGISTS

THE presidential address to the Institution of Metallurgists, delivered by Prof. A. J. Murphy on May 12, covered a field involving not only the metallurgist but also the technologist in general, and in no small measure the pure scientist as well.

After dealing with matters of a more or less domestic nature, Prof. Murphy turned his attention to the general background desirable in the training of the technologist. From this the following has been extracted.

Sooner or later in any discussion on the education of scientists and technologists the remark will be made : "What a pity it is that you cannot give your bright young technical men some sense of cultural values". Often this can be recognized as the defensive manœuvre of a dyed-in-the-wool classicist, who, in an age of automation, atomic energy and satellites, sighs for the day when he could with impunity, and publicly, dismiss science as something they used to call "stinks" at school.

But there is more in it than that. It must be admitted that far too many technically competent men are distressingly inept in communication by speech and writing. This is very regrettable. The blame rests primarily on the schools—of that I do not have the slightest doubt. I do not believe that any reasonably intelligent boy who had been properly taught the elements of English grammar and syntax could perpetrate the mangled compositions which

one encounters alike in Ph.D. theses and the scripts of technical representatives. As for some of the efforts at reported speech which one receives from secretaries of technical committees, one can only regret that the writers have not been able to experience the intellectual satisfaction to be gained from a proper appreciation of the sequence of tenses. The Institution of Metallurgists is trying to do something toward remedying this state of affairs by requiring the demonstration of at least a modest competence in the use of the English language as part of the qualification of a metallurgist. We must hope that by gradual seepage down the line this measure will encourage the schools to increase their efforts in teaching English for use.

We are all fully persuaded that premature and immoderate specialization can produce monsters. Once such damage has been done there is not much hope for rescue operations conducted in university faculties of science and engineering or in technical colleges. Again I think we must look to the schools for salvation. An awareness of what goes on outside his specialization ought to have been gained in the technologist's school days. Special lectures of one hour a week in the liberal arts, isolated from the technological course, make no appreciable impression on deficiencies in this respect which the student has brought with him to the university or technical college.

Somehow time must be found, or regained, in the schools for these opportunities to taste the many savours which go to make a full life. The late Prof. Samuel Alexander said that liberality was the "spirit of pursuit, not a choice of subject". Sir Eric Ashby, in a series of stimulating papers, and lately in his book "Technology and the Academics", has denied that technology and culture are antitheses, and has urged that technology properly taught can provide a path to culture through a man's specialization and not by by-passing it. In this respect technology has the advantage over pure science in its opportunities for developing cultural appreciation, since applied science necessitates contact with one's fellow-men outside one's specialization. If the technologist is to achieve the successful application of his science he must study his fellow man in order to understand his desires, his fears and his needs.

To the man whose training has been along the route of an apprenticeship and a Higher National Certificate qualification, corporate membership of a professional institution opens a door to promotion to positions of major responsibility which otherwise would remain closed. Much could be written about our neglect, during the thirty years or so before and after the beginning of the century, to appreciate the immensely valuable national asset which we possessed in this type of man, and we may yet have cause to regret our improvidence. Apprenticeship in the engineering and metallurgical industries fell into sad disrepute in those days. Less and less did it serve as a springboard for advancement to executive appointments save for men of exceptional ability, whom no system, however bad, could have held back; more and more it became merely a procedure for instilling into the youngster the minimum technical knowledge which operative employment required. In our time we see a new approach. Positive action is taken to encourage and help the young man in industry to broaden his educational horizon and to aim at the most ambitious target which his intellectual ability brings within his scope.

It is a good thing from time to time to count one's blessings. It adds zest to the enjoyment of good times and it helps to keep one's sense of proportion when things are not going so well. Sometimes a piece of good fortune is too obvious to be overlooked. There are also those blessings which become evident only after a little reflexion. In this category comes the privilege which we enjoy in a calling in the absorbing world of science and technology. It is indeed a happy circumstance for us that we make our livings by engaging in an occupation which commands our great interest, even apart from the tangible rewards which economic necessity compels us to exact. When we contemplate the lot of many of our fellow-citizens who must earn their daily bread by the performance of ineffably dull chores, then surely we cannot deny the boon with which by contrast we are favoured.

VISUAL ILLUSTRATION OF UNIVERSITY LECTURES

AT the annual general meeting of the British Universities Film Council, held at University College, Cardiff, on May 8 and 9, one session was devoted to a discussion, under the chairmanship of Prof. G. E. H. Foxon, on the problems of illustrating university lectures by film and related techniques. It was attended by several guests as well as the representatives of the universities on the Council.

Opening the discussion, the guest lecturer, Mr. C. E. Engel, of the Department of Medical Illustration, Guy's Hospital Medical School, and editor of *Medical and Biological Illustration*, took as his subject "The Lecture Theatre of the Future". He pointed out that considerable information was now available on several matters influencing design of lecture theatres, including the visibility of blackboards and of projection screens of different materials. The value of the 'recessed' type of screen was particularly stressed as it allows of sufficient illumination in the theatre for note-taking without impairing the quality of the projected image. Methods involving complicated arrangements of projection are usually considered unsuitable for university use because they upset the speed of the lecture and come between the lecturer and his audience by interposing another person as projectionist. Several devices to overcome this trouble were demonstrated, including: first, a projector for 2 in. × 2 in. slides with automatic slide change and change of focus; and secondly, the prototype of a magazine loading projector for loop films. The details of operation of this loop projector were demonstrated in close-up by closed-circuit television (with apparatus kindly lent by the Marconi Wireless and Telegraph Company), thereby showing another method of lecture illustration. Mr. Engel concluded by pointing out the need for a magazine-loading cine-projector operated by the lecturer by remote control so that the film sequence could be

introduced precisely when required and, if necessary, repeated.

Mr. C. J. Duncan (University of Durham, King's College, Newcastle upon Tyne) said that the normal 'instructional film' with its elaborate production, titling and sound commentary was quite unsuited to the university lecture; what is required is a short piece of film which illustrates only the essential event in which the movement being dealt with occurs. As an example, Mr. Duncan demonstrated how, in describing a piece of apparatus, its components could all be shown by slides, thus enabling the speed of explanation to be varied on different occasions and the moving sequence showing the apparatus in use could be projected at the appropriate moment. This method is of value in that it avoids the necessity of producing a complete film with all the necessary editing and titling, and so is much less expensive than an instructional film; also it is much more flexible and any subsequent modification of the apparatus or technique being demonstrated merely necessitates the substitution of a small piece of film and not the production of a completely new full-length film. These short films lasting some 15–20 sec. can be called 'moving diapositives', and if several are joined together by short lengths of blank film, during which the projector is stopped, several such short sequences can be shown in one lecture without re-threading the projector and thus disturbing the lecture.

Prof. H. I. Stonehill (Royal Military College of Science, Shrivenham) reviewed the use of television as a medium of instruction at college- and university-level in the United States, emphasizing how much this method was being employed there for instruction at all levels. In discussing in more detail its use in universities an account of some assessments of its value was given; apparently, results so far indicate that students 'attending' lectures by television do as well in tests as those actually present in the lecture room. Some students were reported to prefer television lectures because, when concentrating on the screen, they had less difficulty in preventing their attention from wandering than when in a large audience.

Mr. A. M. P. Brookes (Cambridge) described experiments now going on in the Engineering Laboratories at Cambridge where, on account of large numbers, some students were 'attending' the lectures in an adjacent room to which the lecture was televised. The lectures involved were those given by Mr. Brookes himself, and he told of the first attempt and the modifications in technique that had been made in succeeding lectures. Small television cameras can be set up in the lecture room without waste of space, so sited that they cover the movements of the lecturer and show the blackboards clearly. It is important that the lecturer should appear in the picture in reasonable proportion when seen against the blackboard; close-ups which tend to turn the lecturer into a 'television personality' are to be avoided. The necessity for keeping in view of the television cameras does tend somewhat to limit the movement of the lecturer on his rostrum. It is of great importance that the camera covering any one blackboard remains in use long enough for students to copy any diagram or note which it is expected they shall copy. At present, Mr. Brookes and his colleagues are learning by trial and error, but inspection of students' note-books indicates that those receiving the lecture by television make as full notes as those in the lecture-room.

During a general discussion which followed, Mr. Brookes, with the aid of the equipment present, gave a demonstration of 'blackboard work' by television.

This session covered a wide field, and while little summary is possible, attention may be directed to the point made by several speakers that films and television are so well adapted to mass instruction that their possible uses at university-level tend to be overlooked. This is particularly so with films, for although instructional films have been available for many years, suitable film illustration for a university lecture is hard to come by. This, as has already been suggested, is because instructional films are produced as complete entities. There is a need for the provision of short lengths of film illustrating those particular points, which are found in several sciences, when movement plays such an essential part that it cannot be illustrated by other means. Whether this can be done on a commercial basis or whether such sequences, perhaps produced in the course of research, can be exchanged between university departments remains to be seen.

G. E. H. Foxon

THE HALDEN (NORWAY) REACTOR

THE boiling heavy-water reactor of the Norwegian Institutt for Atomenergi at Halden, which is to be used for a joint programme of research and experiment organized by the Organization for European Economic Co-operation, European Nuclear Energy Agency, was successfully operated for the first time on June 29, 1959. The reactor, moderated and cooled with heavy water and fuelled with natural uranium, is located in an excavation in a rock near the paper and pulp factory Saugbrugsforeningen in Halden, 120 km. south of Oslo. It is the first boiling heavy-water reactor in the world, and the first boiling-water reactor in Europe. Besides its main function as a power demonstration reactor for studying problems associated with boiling heavy-water reactor systems, the installation will also produce some 15 tons per hour of process steam in the secondary light-water circuit. Eventually this steam will be used in the paper factory and it is believed that this will be the first nuclear process steam installation.

The reactor was designed at the Netherlands–Norwegian Joint Establishment for Nuclear Energy Research, Kjeller, and was built by the Norwegian Institutt for Atomenergi. The main sub-contractors were the Kvaerner-Myhren, -Thune Combine (mechanical installations), the Chr. Michelsens Institutt (control and instrumentation), Hoyer Ellefsen (civil engineering work), the U.K. Atomic Energy Authority (fuel), and the U.S. Atomic Energy Commission (heavy water). The total cost of the plant, including heavy water and the first uranium fuel load, was 3·5 million dollars.

The Organization for European Economic Co-operation Agreement concerning the reactor was signed in June 1958 by Austria, Denmark, Euratom

(representing Belgium, France, Germany, Italy, Luxembourg and the Netherlands), Norway, Sweden, Switzerland and the United Kingdom. It provides for a joint programme, budget and staff for research and development work with the reactor for a period of three years. Through agreements with the Institutt for Atomenergi, the United States and Finland are also associated with the reactor project. At present, a professional staff of thirty, recruited from the participating countries, is attached to the project. During the next six months the reactor will be operated at low power-levels to enable fundamental reactor physics experiments to be performed. After this period the power level will be increased gradually up to the design power of 10 MW. thermal energy.

The reactor plant will be officially opened by H.M. King Olav on October 10.

The Halden Reactor Project is one of several joint undertakings sponsored by the European Nuclear Energy Agency of the Organization for European Economic Co-operation ; others are the 'Eurochemic' company for the chemical processing of irradiated fuels (established by an international convention signed in December 1957) and the *Dragon* high-temperature gas-cooled reactor project, work on which began last April.

THE DANISH ATOMIC ENERGY COMMISSION

THE report on the activities of the Danish Atomic Energy Commission* for the period April 1, 1957, to March 31, 1958, deals mainly with the erection of the Riso Research Establishment and the three reactors *DR*1, *DR*2 and *DR*3, and the work of the six departments of the Establishment. The membership of the Commission remained unchanged during the period under review, and Prof. Niels Bohr continued to act as chairman. The total cost of the Establishment was originally estimated at about 100 million kroner. The expenditure so far, including that estimated for 1958–59, is about 90 million kroner, of which about 60 million kroner is for expenditure on buildings and the remainder for the three reactors and the requisite technical and scientific equipment. On March 26, 1958, the Finance Committee authorized an additional expenditure of up to 2·5 million kroner on a linear accelerator to be used for experiments on the preservation of food and for other irradiation experiments.

On August 15, 1957, the first of the three reactors began to operate, and by September the chemical, reactor engineering, electronics and physics laboratories together with the administration building were completed and in use. Then followed the health physics department, the library and the canteen, and early in 1958 the agricultural department, the lecture hall and the buildings to house the *DR*2 reactor group were completed, leaving only the buildings for the *DR*3 reactor to be erected. A detailed map attached to the report shows the complete layout of the Establishment.

In the physics department one group has been working on the construction of a laboratory for investigations of beta- and gamma-ray activities ; another group with neutron spectroscopy ; and a third group with solid state physics, particularly the study of the effects of radiation damage to metals and graphite. A study has also been made of the literature on deuterium fusion and of the theoretical aspects of the utilization of the energy from deuterium fusion. The electronics department has undertaken active research on scintillation counters and on the development of a reactor simulator. Two study groups were formed in the reactor engineering department. The first was engaged in drafting a project for a heavy-water-moderated power reactor with an organic cooling medium, and the second for a high-temperature gas-cooled reactor.

A section of the report is devoted to the International Atomic Energy Agency, and to regional co-operation in Europe, including the Organization for European Economic Co-operation and Euratom. The report also gives details of geological surveys in Greenland ; relations between the Commission and commerce and industry ; educational activities which included experimental reactor courses with *DR*1 and lecture courses at the Technical University of Denmark ; and general information services.

* Report on the Activities of the Danish Atomic Energy Commission for the period from 1 April 1957 to 31 March 1958. Pp. 62. (Copenhagen : Danish Atomic Energy Commission, 1958.)

ATOMIC POWER CONSTRUCTIONS, LTD.

ATOMIC POWER CONSTRUCTIONS, LTD., 28 Theobalds Road, London, W.C.1, which was formed in December 1956, is carrying out extensive research and development in connexion with the national nuclear power effort. The research programme is concentrated at the company's laboratories at Heston, Middlesex, and a booklet* recently prepared gives a survey of the problems being tackled. In the Calder Hall type of reactor the uranium is arranged in a pattern of vertical rods embedded in a large cylindrical 'core' of graphite. The heat generated in the rods is carried away by blowing carbon dioxide gas past them, and in order to economize in pumping power the reactor designer puts the whole of the carbon dioxide gas circuit under a pressure of some 20 atmospheres. Consequently, the core and uranium must be enclosed in a pressure vessel.

Most stringent precautions must be taken against failure of the pressure circuit in which the carbon dioxide circulates, and a major part of the work undertaken by Atomic Power Constructions, Ltd., is concerned with proving the materials and fabrication techniques which are used in the construction of the pressure vessel. An important problem is creep of the steel to be used for the pressure vessel and for the heat exchangers, and in order to acquire the necessary information sufficiently quickly an air-conditioned creep laboratory containing a battery of seventy creep machines has been set up. The strain ageing of steels at elevated temperatures ; weld-

* Research and Development at the Heston Laboratories of Atomic Power Constructions, Limited. Pp. 10. (London : Atomic Power Constructions, Ltd., 1959.)

ability and welding techniques for use with selected steels; and the chemical compatibility of the various materials used in the reactor with the carbon dioxide coolant gas, are some of the other problems being investigated by the Metallurgical Division. A considerable expansion in facilities is planned during 1959, and additional long-term researches relating to uranium, magnesium and the weldability of steel will be started. The design of the best heat transfer surface for the fuel elements is at present largely empirical and at the Heston Research Laboratories two experimental rigs are provided for experimental tests. In both, the fuel element can is placed in a working section and the heat developed in the uranium simulated by an electric heater. Facilities for basic studies in heat transfer and in other design problems have also been set up, and these facilities comprise a flow visualization rig and associated equipment in which water replaces the pressurized carbon dioxide as the working fluid.

Crompton Parkinson, Ltd., the Fairey Aviation Co., Ltd., International Combustion (Holdings), Ltd., Richardsons Westgarth and Co., Ltd., and Nuclear Civil Constructors (Trollope and Colls, Holland and Hannen, and Cubitts) form the five member companies of Atomic Power Constructions, Ltd.

COFFEE RESEARCH IN THE BELGIAN CONGO

TWO investigations of a fundamental character on the genus *Coffea* have recently been published by the Institut National pour l'Étude Agronomique du Congo Belge, (i) Recherches sur l'Autostérilité du Caféier Robusta (*Coffea canephora* Pierre) by M. Devreux, G. Vallaeys, P. Pochet and A. Gilles (No. 78. 1959. Pp. 44+8 plates. 40 francs); (ii) Recherches sur les Affinités Chromosomiques dans le Genre *Coffea* by J. Bouharmont (No. 77. Pp. 94+2 plates. 70 francs). The self-sterility of Robusta coffee has been known in a somewhat confused way for many years, but no convincing demonstration of this phenomenon has previously been presented. This information is important in preparing a rational programme of selection. The investigators of the work indicated above have now shown, under strictly experimental conditions, that this variety is quite self-sterile. As a result of many controlled self-pollination experiments, using 19 clones and based on a very large number of flowers, for example, more than 15,000 in one instance, an extremely small number of fruits has been obtained, the highest percentage not exceeding 0·24. By contrast, when the flowers of the same clones were subjected to cross-pollination, a number of ripe fruits, 30–40 per cent, was obtained. The self-sterility is not attributed to defects in floral structure or in micro- or macrosporogenesis but to anomalies in the formation and growth of the pollen-tubes. In no case were these able to traverse the style. While a genetical explanation in terms of incompatibility may be advanced, validation has still to be obtained.

Observations on the chromosome numbers of thirteen species of *Coffea*, including all the well-known species such as *C. arabica*, *C. liberica*, *C. stenophylla*, etc., have shown that all those examined are diploid with 22 chromosomes, except *C. arabica* which has 44. Certain hybrids are diploid and others tetraploid. The nuclear behaviour at mitosis is apparently identical in all the species. Measurements of chromosome lengths show that these are all much alike. It is considered that these comparisons by measurement confirm the close systematic relation of certain species, but it does not enable a general classification of the genus to be established. An average idiogramme of the African *Coffea* has been prepared. The author concludes that the genus is a very homogeneous one, and that the species investigated are closely related from the cytological point of view. Lastly, this investigation has yielded no evidence of difficulties in obtaining interspecific hybrids.

BOTANY IN SCOTLAND

AN agreeable and very well-deserved tribute has been paid to Prof. J. R. Matthews, regius professor of botany in the University of Aberdeen, by his friends, past and present colleagues and former students, on the occasion of his seventieth birthday. During his twenty-five years as regius professor he has greatly increased the stature of his Department, has helped the cause of botanical science by his work on the councils of various societies and has made many valuable contributions to botany, especially in the field of research relating to the origin and distribution of the British flora. The presentation volume under consideration has been printed for the Botanical Society of Edinburgh and appears as a special number of the *Transactions* (38; March 1959. 15*s*.). There is a foreword by H. R. Fletcher, and, as might perhaps be expected, a number of the articles relate to the ecology of Scottish plants. But there are also some contributions dealing with other aspects of botanical science, for example, "Some Fundamental Considerations on the New Morphology", by H. J. Lam; "Peristome Teeth and Spore Discharge in Mosses", by C. T. Ingold; a biographical essay on "The Rev. John Walker (1731–1804)—a Notable Scottish Naturalist", by G. Taylor, of the Royal Botanic Gardens, Kew; and J. Grant Roger has contributed a useful article on the "Conservation of the Scottish Flora".

Further evidence of the work of this distinguished and active botanical society has also been published (*Trans.*, 37, Part 4; 1959). This is devoted entirely to various aspects of Scottish botany. Thus there are floristic studies of a number of different regions, sometimes combined with geological observations. D. Ratcliffe has contributed an article on the "Habitat of *Koenigia islandica*"; and D. G. Downie on "*Rhizoctonia solani* and Orchid Seed". There is a special cryptogamic section by D. M. Henderson and an alpine section by D. Grant Roger. There is also a useful general article dealing with botanical research in Scotland. This gives a brief account of the activities of the main research institutes, including those devoted to marine biology and nature conservancy, but it is not concerned with university departments of botany.

HABIT OF ICE CRYSTALS GROWN IN HYDROGEN, CARBON DIOXIDE AND AIR AT REDUCED PRESSURE

By A. P. van den HEUVEL and Dr. B. J. MASON
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ICE crystals grown from the vapour in air at normal atmospheric pressure show a remarkable variation of crystal habit with temperature. This has been closely investigated by Hallett and Mason[1] by growing crystals on a thin fibre running vertically through the centre of a diffusion cloud chamber in which the vertical gradients of temperature and supersaturation were accurately controlled and measured. The results of many experiments covering a temperature range of 0 to −50° C. and supersaturations varying from a few per cent to about 300 per cent (in very clean, droplet-free air) consistently showed the crystal habit to vary along the length of the fibre in the following manner: 0° to −3° C., thin hexagonal plates; −3° to −5° C., needles; −5° to −8° C., hollow prisms; −8° to −12° C., hexagonal plates; −12° to −16° C., dendritic stellar crystals; −16° to −25° C., hexagonal plates; −25° to −50° C., hollow prisms. These changes of habit were controlled almost entirely by the temperature, the supersaturation influencing only such secondary features as the growth-rate and the onset of dendritic and needle growth. Similar conclusions have been reached by Kobayashi[2].

In attempting to account for these changes of habit, considerable interest is attached to recent reports by Isono *et al.*[3,4] that they are further modified if the crystals are grown in an atmosphere of hydrogen instead of air, but that little change is effected by replacing air with carbon dioxide. In particular, Isono found that crystals grown in a water-saturated air at −7° C. developed preferentially along the *c* axis to form hexagonal prismatic columns; but, in hydrogen, the growth-rates in the *a* and *c* directions were approximately equal. Furthermore, needle-like crystals grown in air thickened, and skeletal growth was suppressed when the air was replaced by hydrogen. Crystals grown at −16° C. in air took the form of thin hexagonal plates, but those grown in otherwise similar conditions in hydrogen developed as thick plates and short hexagonal columns.

In general, the effect of hydrogen was to produce more nearly isotropic growth and isometric crystals, changes which were attributed to the high diffusion coefficient of water vapour in hydrogen, it being 3·4 times that in air. The fact that crystals grown in carbon dioxide were very similar to those grown in air at the same pressure was taken to be consistent with the diffusivity being only 0·7 times that in air.

If the rate of diffusion of water vapour were an important factor in controlling crystal habit, very similar results to those obtained in hydrogen should be obtained in air at reduced pressure since the diffusivity is inversely proportional to the air pressure. Indeed, Kobayashi[2] and Isono[4] report that reduction of the air pressure does influence the shapes of crystals grown in both diffusion- and mixing-cloud chambers.

Isono found that his results obtained at −7° and −16° C. in hydrogen were reproduced in air at pressures of 80–20 mm. mercury. Kobayashi reports that the hexagonal plates and dendritic crystals found at temperatures between −10° C. and −20° C. in air at normal atmospheric pressure persist if the pressure exceeds 300 mm., but, at less than 100 mm. pressure, they are entirely replaced by hexagonal columns, often with hollow cavities, and, at less than 70 mm. pressure, by short solid columns which now occur at all temperatures between 0° C. and −30° C. Unfortunately, under the conditions of the experiment, the total pressure could not be lowered without also lowering the supersaturation of the vapour, and Kobayashi attributes the formation of solid prismatic columns at low air pressures to the slow growth conditioned by the low supersaturation. He supports this view by recording that in air at normal atmospheric pressure only solid columns are obtained in

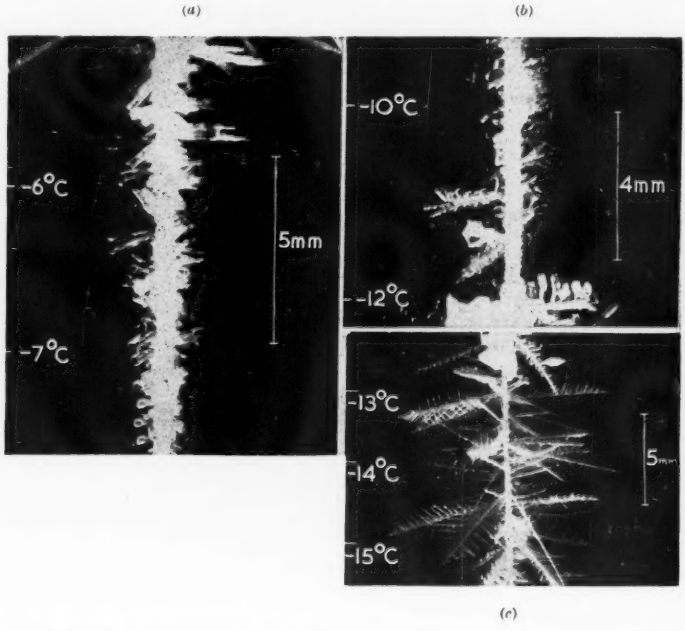

Fig. 1. Ice crystals growing in an atmosphere of hydrogen on a fibre suspended in a diffusion cloud chamber

a, Needles and hollow prisms in the temperature range −5° to −7·5° C.; *b*, plates between −9° and −12° C.; *c*, dendrites between −12° and −16° C.

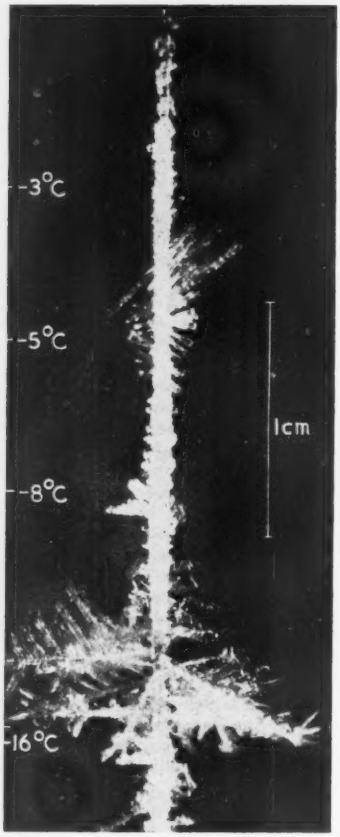

Fig. 2. Crystals grown in air at 80 mm. mercury pressure. The sequence is plates → needles → hollow prisms → plates → dendrites → plates as the temperature varies from 0° to −20° C.

the temperature range 0° to −30° C. providing the supersaturation does not exceed 7 per cent with respect to ice.

Because the results of these Japanese experiments in hydrogen and in air at low pressure, if confirmed, might throw new light on the mechanism responsible for the remarkable habit changes in ice, similar investigations have been made by us.

The crystals were grown, in aerosol-free air, in the diffusion cloud chamber described by Hallett and Mason[1]. They were supported on a fine fibre along which the temperature varied from 0° to −50° C. and the supersaturation could be varied and measured over a wide range. In a chamber filled with hydrogen at atmospheric pressure, the crystals exhibited the same variation with temperature as listed above for crystals grown in air (Fig. 1). No differences were observed except that the crystals grew much faster in hydrogen, in conformity with the diffusion coefficient of water vapour being 3·4 times that in air, and the thermal conductivity, which controls the rate of dissipation of the latent heat of crystallization, being about seven times greater.

Crystals were also grown under reduced air pressures of 300, 150, 80, 40 and 20 mm. mercury, the pressure never varying by more than 1–2 mm. during the course of any one experiment. Again, as shown in Fig. 2, the habit varied with temperature in a manner identical to that observed at normal atmospheric pressure and dendritic forms could always be produced between 0° C. and −3° C., and also between −12° and −16° C., at high supersaturations.

Crystals were grown under low supersaturations at atmospheric pressure between two parallel sheets of ice maintained at slightly different temperatures. This arrangement allowed the temperature and supersaturation to be accurately determined. Under supersaturations not exceeding 5 per cent with respect to ice, plate and sector-plate crystals appeared in the temperature range −10° to −15° C. and therefore the experiments provided no support for Kobayashi's claim that only solid prismatic columns occur at all temperatures between 0° C. and −30° C. at such low supersaturations.

Summarizing, we have been unable to confirm that the habit of ice crystals grown from the vapour is essentially modified by growing them in either hydrogen or in air at reduced pressure, although their growth-rates are affected in the sense one would expect from the manner in which the diffusivity and thermal conductivity of the environment would influence the fluxes of water vapour and heat.

We are unable to offer an explanation of the results obtained by the Japanese workers except to suggest that, perhaps, their apparatus may have been contaminated with small traces of foreign vapours such as are known[5] to affect markedly the ice-crystal habit even though present in only very small quantities.

[1] Hallett, J., and Mason, B. J., *Proc. Roy. Soc.*, A, **247**, 440 (1958).
[2] Kobayashi, T., *J. Met. Soc. Japan*, **36**, 193 (1958).
[3] Isono, K., Komabayashi, M., and Ono, A., *Met. Papers Geophys. Inst. Tokyo Univ.*, **8**, 327 (1958).
[4] Isono, K., *Nature*, **182**, 1221 (1958).
[5] Hallett, J., and Mason, B. J., *Nature*, **181**, 467 (1958).

CELL-WALL MUCOPEPTIDES OF *STAPHYLOCOCCUS AUREUS* AND *MICROCOCCUS LYSODEIKTICUS*

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A CONSIDERABLE number of recent studies have been concerned with the superficial layers of micro-organisms. In particular, insoluble material which is resistant to the action of several proteolytic enzymes and nucleases has been isolated. The morphology of this material is such that it may be regarded as consisting of the cell walls. Lysozyme-sensitive micro-organisms yield walls which are dissolved by lysozyme. In Gram-positive species the material has a relatively simple overall chemical composition compared with that of the cytoplasmic proteins, and its biosynthesis is inhibited by antibiotics such as penicillin and bacitracin. Elucidation of the more detailed chemistry of the structure and

biosynthesis of the cell wall holds, therefore, the hope of a further understanding of the mode of action of antibiotics. The purpose of the present article is to discuss some recent observations made in these laboratories and elsewhere in relation to concepts about the structure and biosynthesis of the cell walls of, in particular, staphylococci and micrococci.

The work of Salton[1] and Cummins and Harris[2] firmly established that a large proportion of the substance of cell walls of representative strains of several species of Gram-positive cocci, other than some streptococci, consists of a limited number of amino-acids, two amino-sugars and sometimes one or two hexoses; these component substances were detected on paper chromatograms of acid hydrolysates of the wall structures. The name mucopeptide[3] has more recently been proposed to describe the group of polymeric substances containing these compounds. The earlier work was not designed to give an exact indication of the quantitative interrelationship between the components or to express any attitude towards the number of polymers combined to give the final insoluble wall structure. Suggestions of possible heterogeneity at the polymer-level were, however, contained in the earlier work of Mitchell and Moyle[4], who had isolated from a cell fraction they called "cell envelopes", polyol phosphate compounds. Cell walls prepared by the Salton and Horne[5] method were known to contain small amounts of phosphorus, and later Baddiley[6] and his colleagues first obtained substances which they called teichoic acids from *Lactobacillus arabinosus*. One component of teichoic acid associated with the wall structure was polyribitol phosphate carrying in covalent linkage either glucose or N-acetylglucosamine to which, in turn, alanine was bound in ester linkage. This type of substance was shown to be present in cocci[6]. Its amount varied from negligible quantities in walls from *Micrococcus lysodeikticus* to about 30 per cent in the strain of staphylococcus wall examined; these quantities were deduced from the phosphorus contents of the walls—only a small proportion of the calculated material is recorded as having been isolated. Mitchell and Moyle[7] have recently shown that their polyol phosphate also contains ribitol phosphate. The presence of substances of this type which can be extracted by cold trichloroacetic acid may explain the report[8] of the presence of components soluble in trichloroacetic acid and in water in frozen dried wall preparations.

The homogeneity or heterogeneity of the structure remaining (that is, the mucopeptides) after the removal of teichoic acid is still unjudged. Examination of the concentration of amino-acids in the mucopeptides from various strains of staphylococci and micrococci shows that considerable differences in the molecular proportions occur. Moreover, the ratios for most of the strains do not fit any simple pattern. Even if the small amounts of alanine present in the teichoic acid in walls from some strains cause some distortion of the values for the concentration of this amino-acid in the mucopeptide, such considerations do not apply to the other amino-acids. Park and Strominger[9] have suggested that a uridine–muramic acid peptide originally isolated by Park[10] from penicillin-treated staphylococci may be a biosynthetic precursor of mucopeptide. This peptide had its amino-acids (alanine, glutamate and lysine) in simple molecular proportion and resembled in this respect the wall mucopeptide. If this compound should eventually prove to be a precursor, then presumably other precursor compounds corresponding to the glycine and glucosamine present in the wall must be found. The molecular ratios for the amino-acids in other strains of staphylococci or micrococci such as 11, 524 or *lysodeikticus* are not simple and the condensation of a single small peptide could not account for them. If, however, there is more than one mucopeptide in the wall and possibly a multiplicity of uridine peptide precursors, as has been suggested by Ito, Ishimoto and Saito[11], then this situation is more easily explained.

Table 1. AMINO-ACID COMPOSITION OF CELL WALLS EXPRESSED AS MOLAR RATIOS (GLUTAMATE TAKEN AS 1·0) IN SEVERAL STRAINS OF STAPHYLOCOCCI AND MICROCOCCI

Strain	Glutamate	Alanine	Glycine	Lysine	Ref.
524/*SC*	1·0	1·8	3·2	0·6	3
H	1·0	3·2–3·7	—	0·9–1·2	9
Duncan	1·0	2·8	6·3	1·9	23
11	1·0	1·4	0·05	0·5	Present work
Oxford	1·0	1·9	4·9	1·0	Present work
M. lysodeikticus	1·0	1·9–2·5	1·2–1·6	1·0	13

Cell walls prepared by the Cummins and Harris method, hydrolysed for 4 hr. with 4 *N* hydrochloric acid and the contents of amino-acids determined (ref. 13).

The action of lysozyme on a 'staphylococcus' strain 11 has provided some facts which also point towards possible heterogeneity of the wall mucopeptides. This organism has a wall which is qualitatively similar to staphylococci, as can be seen from Table 1, although it is distinguished by a very low glycine content. No glucose could be detected. Its cytochrome composition, however, is different from other staphylococci and nearer that of *Micrococcus lysodeikticus* (Jackson, private communication).

Fig. 1 shows the lysis of whole organisms of this strain by lysozyme. When the enzyme is allowed to hydrolyse wall preparations, the optical density of the suspension falls to about 26 per cent of the

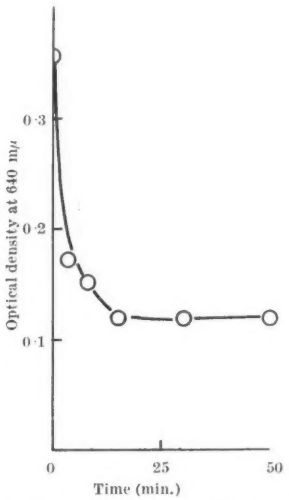

Fig. 1. Lysis of 'staphylococcus' strain 11 by lysozyme. A suspension of organisms grown in broth for 18 hr. at 35° with agitation was prepared by centrifuging, washing twice with water, and suspending in 0·1 *M* ammonium acetate buffer *p*H 6·0. To the suspension warmed to 37° 50 μgm./ml. of crystalline (Armour Products, Ltd.) lysozyme were added at zero time. The optical density was measured at the times indicated during incubation at 37°

Table 2. Amino-acid and Glucosamine Contents (expressed as Molar Ratios with Glutamate as 1·0) of the Lysozyme Soluble and Lysozyme Insoluble Parts of the Cell Wall Mucopeptides of 'Staphylococcus' Strain 11

	Whole wall	Lysozyme residue	Lysozyme soluble
Glutamate	1·0	1·0	1·0
Alanine	1·4	1·4	1·5
Glycine	0·05	0·07	0·05
Lysine	0·5	0·6	0·5
Glucosamine	0·6†	0·46*	0·81*

* Estimated on the hydrolysate after separation of the muramic acid (cf. Perkins and Rogers, ref. 13).

† Estimated from a comparison of the ninhydrin colour on chromatograms when compared with that given by standard amounts of glucosamine.

initial value during 24-hr. incubation at 35°. Nevertheless, on centrifuging at 10,000*g* for 10 min. only about 40 per cent of the material in the hydrolysate remains in solution. Table 2 shows the molecular composition of the soluble and insoluble parts. More definite evidence of heterogeneity has been demonstrated in walls from *B. subtilis* (Janczura and Rogers, unpublished observation).

These walls contain many more amino-acids than those in staphylococcus[1], but lysozyme liberates soluble material from them containing principally alanine, glutamate, diaminopimelic acid, glucosamine and muramate but leaves behind as a small insoluble residue material containing eleven or twelve amino-acids. Biochemical heterogeneity of this type may well reflect the multiple-layered nature of the cell wall which has been revealed by electron microscopic examination of sectioned bacteria[12]. It is with the possibility of heterogeneity of mucopeptides in mind that the following structural and biosynthetic results must be interpreted.

Structural Observations

Hydrolysis of M. lysodeikticus wall. Brief hydrolysis of walls from *M. lysodeikticus* for 20 min. with 2 *N* sulphuric acid at 100° has yielded[13] three fragments, one of which (*a*) contains muramate and the four amino-acids, while two have relatively simple composition; one (*b*) contains amino-sugars in the proportion of two moles of muramic acid to one of glucosamine, the other (*c*) one mole of glucosamine, one of muramate and one of glycine. The amino-group of the glycine in compound (*c*) is not free to react with fluorodinitrobenzene and it is therefore, reasonable to suppose that the carboxyl of the muramate is linked with the $—NH_2$ group of the glycine. As isolated, the $—NH_2$ groups of some of the hexosamine are free, but in the original structure before hydrolysis they are probably acetylated. The oligosaccharide (*b*) is different both in its electrophoretic and chromatographic behaviour from the oligosaccharide isolated by Salton[14] from hydrolysates of the wall resulting from the action of lysozyme, as might be expected from the molecular composition of the latter which contains[15] equimolar amounts of N-acetylmuramate and N-acetylglucosamine rather than the two moles of muramate to one of glucosamine present in the acid hydrolysis product.

Closer examination of the action of lysozyme on walls of *M. lysodeikticus* has revealed certain fallacies in the literature in the interpretation of results. It has been recognized since the earliest studies of lysozyme that material reacting in the Elson–Morgan[16] N-acetylglucosamine test is liberated. Recently a claim has been made[17] that larger amounts of material reacting as glucosamine rather than N-acetylglucosamine are released. Examination[18] of this latter claim has, however, shown that it is likely to be partly due to the reaction of liberated reducing groups from combined N-acetylamino sugars reacting with the free[18] ε-amino groups of lysine to give artefact colour[19] in the test and is not due to hexosamine with free amino groups. The reducing group of glucose itself which is also present in the wall of *M. lysodeikticus* is not necessarily involved since a similar artefact colour can be obtained from lysozyme digests of walls from the lysozyme-sensitive strains of 'staphylococcus' such as strain 11, in which, as has been shown, no detectable glucose is present.

Examination[15] of the colour formed in the N-acetylglucosamine test has revealed a more complicated situation. The basis of the test is the heating of the substance in dilute alkali—either sodium carbonate[16] or borate[20], during which heterocyclic ring substances which react to give colour with *p*-dimethylaminobenzaldehyde are formed. Examination of the time course of chromogen formation in lysozyme hydrolysates of walls during treatment with alkali reveals that smaller molecular material in them is hydrolysed by alkali under the conditions of hexosamine tests, presumably to give free reacting N-acetylglucosamine and N-acetylmuramic acid groups which are rapidly converted to chromogen. Thus, the amount of 'N-acetyl-hexosamine' estimated depends upon the degree of alkaline hydrolysis which has taken place in the test. Previous results for liberation of 'N-acetylglucosamine' from cell wall material by lysozyme probably reflect more upon the alkali treatment used in the method of estimation than upon the action of the enzyme itself; no free 'glucosamine' is liberated. Oxidation of the disaccharide liberated by lysozyme with hypoiodite followed by hydrochloric acid hydrolysis gave no glucosaminic acid but did give a substance which may be the lactam derived from the C-1 carboxylic acid corresponding to N-acetylmuramic acid; at all events, isolated N-acetylmuramic acid gave the same substance after hypoiodite oxidation and acid hydrolysis[15].

Thus the lysozyme-produced disaccharide accounting for about 15–16 per cent of the total hexosamine in the wall is likely to be 1–4 or 1–6 N-acetylglucosaminido-N-acetylmuramic acid. This assumes, for the present, that this disaccharide is not a product of a transglycosidation rather than a hydrolysis. Other evidence shows the linkage almost certainly to be 1–6. No evidence is yet available about the bond between C-1 of N-acetyl-muramic acid and N-acetylglucosamine; but we may for the moment suppose that part of the mucopeptide or part of one of the mucopeptides is made up of N-acetylglucosaminido-1–6 N-acetyl muramic acid with the carboxyl group of the muramate free and partly of a disaccharide in which this group is combined with glycine.

If the larger, more complicated peptide isolated from acid hydrolysates comes from the same polymer, then the rest of the amino-acids may occur as a sequence linked to the glycine. This discussion leaves glucose out of account. Peptide amino-sugar fragments also containing glucose have been isolated from acid hydrolysates of the cell walls and it seems likely that glucose does not occur in the form of a separate polymer. It is very rapidly released[13] during dilute acid hydrolysis of the wall, a behaviour reminiscent of that of fucose in the blood group substances.

We have then the following evidence about structures in the wall. (1) N-acetylglucosaminido-1-6-N-acetylmuramate occurs to the extent of at least 15 per cent of the total hexosamine. (2) Glycyl-N-acetyl-muramido-N-acetylglucosamine or N-acetyl-glucosaminido-1-6-N-acetylmuramyl-glycine occurs. (3) The glycine of (2) may be further linked to a peptide chain containing glutamate, alanine and lysine. (4) A lysozyme-resistant[13] structure containing two molecules of muramate and one of glucosamine exists in the molecule. (5) Lysozyme so fragments the molecule that the following are formed: (*a*) the disaccharide already mentioned; (*b*) at least three substances diffusible through 'Cellophane' which contain both glucosamine, muramate and the four cell wall amino-acids but no glucose; (*c*) three large non-diffusible substances[14] which have some amino-sugar and almost all the glucose associated with them. This profound fragmentation of the molecule suggests that the lysozyme labile bond is scattered through the molecules of the polymer or polymers rather than occurring at frequent regular intervals as part of an unbranched backbone mucopolysaccharide chain. It is clearly too early to speculate further about the structure of the mucopeptides. The optical specificity of the amino-acids in the various fragments has not yet been examined, although it is known that a proportion of the alanine[9,21] and all the glutamate in the walls of some strains of *Staphylococcus aureus* and in *Micrococcus lysodeikticus* is in the –D form.

Biosynthesis of Staphylococcal Mucopeptides

Biosynthesis of the mucopeptides is in some respects a less complicated process than that of cell proteins; it can occur under conditions where protein formation will not occur, such as when a single cell wall amino-acid is supplied to the organism[3,22] when chloramphenicol is added to staphylococcal suspensions, thus stopping ordinary protein synthesis[3,22,23], or in *B. subtilis* when aza-guanine is present, which also brings to a halt protein synthesis[24]. The process of mucopeptide synthesis is, nevertheless, sensitive to penicillin[3,25], whereas protein synthesis is not[26]. Even in the presence of penicillin, however, synthesis of cell wall material by suspensions of some strains of staphylococci continues for a time at a reduced rate[3]. During this time abnormal mucopeptide is formed, with a smaller content of alanine relative to the amount of glutamate[3]. The biosynthesis of the ribitol phosphate teichoic acid is also stopped by penicillin[4,7].

In some strains, but not in others, a uridine muramyl peptide already referred to accumulates[2,9,10]. In another strain more complicated uridine peptides accumulate[11], but the walls of the organism were found[27] to be more complicated. Whether or not the uridine peptides are precursors of cell wall mucopeptides remains to be proved; that uridine compounds of the amino-sugars should be involved in building up the glycosidic bonds in the structure is eminently reasonable from other work on mucopolysaccharide and polysaccharide biosynthesis, and uridinediphosphomuramate has been reported as being present in other species of organisms[18]. Also present within *Streptococcus faecalis*[29] and, as we have shown, within *M. lysodeikticus* and *Staphylococcus aureus*, are larger peptides containing the same hexosamines and amino-acids as the cell wall. Amino-acid is incorporated rapidly into some of these peptides (Rogers, H. J., and Mandelstam, J., unpublished observations), so they also may play some part in mucopeptide biosynthesis.

Table 3. Effect of Dilution on the Efficiency of a Staphylococcal Suspension in Synthesizing Mucopeptide

Mass of organisms added (μgm.)	Vol. of supernatant	Total counts/min. incorporated	Total counts/min. mgm. D.W.* × 10^3
0	0·5	57	—
12	0·5	225	14
62	0·5	563	8·1
125	0·5	870	6·5
250	0·5	1,600	6·2
12	0	118	9·8
250	0	920	3·7
1,000	0	1,975	1·9

* mgm. D.W. = mgm. dry weight of bacteria added per ml. of system.

Organisms (*Staphylococcus aureus* strain 524) in suspension and crush supernatant were added to make a final volume of 2·5 ml. and final concentrations of 0·5 μmole of ATP and UTP, lysine and glutamate, 1·0 μmole of alanine, magnesium, cysteine and 0·22 *M* sucrose were present. Radioactively labelled glycine: 1·5 μmoles/ml. of glycine were added containing 0·085 μc. of radioactivity as ^{14}C; 1 μc. of glycine gave 2·09 × 10^8 counts per min. in the counting apparatus used: the mixtures were incubated for 90 min. at 37° and the reactions were stopped by the addition of trichloroacetic acid to a final concentration of 5 per cent (w/v). Purified cell wall (10 mgm.) was added as carrier before the trichloroacetic acid at the end of the experiment. The samples were then treated as for 'T.C.A. mixed precipitates' (ref. 3). The broken suspension was made by crushing the suspension in *M* sucrose containing cysteine, magnesium and phosphate in the Hughes press working at −25° to −30°. The broken preparation was then diluted to ten times its initial volume with 0·1 *M* phosphate at *p*H 7·0 and centrifuged for three periods of 15 min. at 1,000*g* at 0–4°; between each spinning the sediment was removed. The final supernatant was used.

In order to further the study of these possible intermediates, it would clearly be desirable to have some system in which the selectively permeable membrane of the living organism is no longer functional. Attempts to produce active preparations free of whole living cells similar to those which others have found capable of incorporating amino-acids into cell walls[30,31] have not so far been successful. Initial experiments were very hopeful so long as the efficiency of the remaining unbroken organisms was regarded as being independent of the dilution of the suspension and the presence of 'cell sap'. As Table 3 shows, however, this is not so, and even when the number of whole cells was not more than 0·05–0·1 per cent of those in the initial cell suspension the incorporating activity was equivalent to 10 per cent of that by the whole unbroken preparation. Part of the stimulating activity of the 'cell sap' was shown to be due to its content of nucleic acid (Table 4), a striking parallel with previous observations[30] made with broken cell preparations. Some degree of specificity existed, in that nucleic acid isolated by the technique of Jones[32] from the strain of staphylococcus examined was much more effective than thymus deoxyribonucleic acid. In another type of experiment, living cells were labelled in their cell walls, added to part of the crush,

Table 4. Stimulation of Cell Wall Synthesis by Nucleic Acids Isolated from *Staphylococcus aureus* Strain 524

	Total counts/min./mgm. added cells × 10^3		
	Mixed TCA ppt. Exp. 1	Mixed TCA ppt. Exp. 2	Cell walls Exp. 1 and 2
No additions	3·7	3·7	3·7
+ Supernatant	10·7	10·0	9·90
+ Nucleic acid	9·0	9·2	9·30

The conditions for incubation were as described in the legend to Table 3. The supernatant was the same as for the experiment shown in Table 3 and was replaced where indicated by 0·15 mgm./ml. of nucleic acid (mixture of deoxyribonucleic acid and ribonucleic acid in the proportions of 7 : 1) isolated from *Staph. aureus* 524 and 50 μgm./ml. of cells were added. Carrier cell wall was added as previously described (cf. Table 3) and cell walls were re-isolated by the Cummins and Harris (ref. 2) procedure.

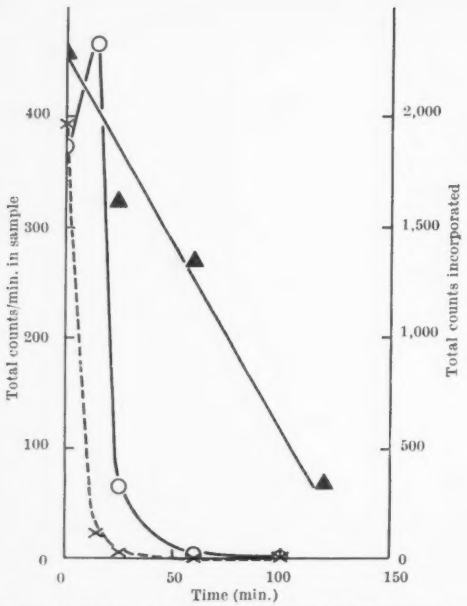

Fig. 2. The sedimentation of whole cells from a broken preparation during centrifugation at 1,000*g* at 0–4°. Whole cells of *Staphylococcus aureus* strain 524 were labelled in their cell walls by incubation with labelled glycine (ref. 22), washed and prepared as a thick suspension which was then added to the diluted crush. The crush was prepared from *Staphylococcus aureus* strain 524 by passing a thick suspension of cells in *M* sucrose through the Hughes press working at −30°. The crush was then diluted with either 0·1 *M* sodium–potassium phosphate buffer, *p*H 7·0×, or with further *M* sucrose (▲). At the times indicated the centrifuge was stopped, and samples taken from the supernatant. In order to obtain as representative samples as possible without disturbing the sediment, the pipette was moved slowly down the tube while the sample was drawn into it. The samples were mixed with trichloracetic acid to give a final concentration of 5 per cent (w/v) and the precipitate washed once with 5 per cent trichloroacetic acid and dried by washing with acetone and ether. The dried precipitates were weighed and assayed for radioactivity at infinite thickness. Total radioactive counts (that is, weight × specific activity) are recorded. ○ shows the ability of samples of the supernatants to incorporate radioactive glycine into cell wall material when tested under the conditions given in the legend to Table 3

and incorporating activity of the cell wall and residual radioactivity due to whole cells remaining in the supernatant after centrifugation at 0–4° compared. Two observations from Fig. 2 can be made: (1) that centrifugation at 1,000*g* in the presence of sucrose can be a very inefficient way of removing whole cells; (2) a difference between the rate of deposition of whole cells and the incorporating activity of the preparations is apparent, thus suggesting that incorporation might be taking place into some particle less dense than the whole cell. This difference, however, can be largely accounted for by the increasing efficiency of the decreasing number of whole cells.

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RELATIONSHIP BETWEEN PHOTOPHOSPHORYLATION AND THE HILL REACTION

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ARISING from the work of Hill[1], it is now well known that isolated chloroplasts illuminated in the presence of a suitable hydrogen acceptor will evolve oxygen:

$$2A + 2H_2O \xrightarrow[\text{chloroplasts}]{\text{light}} 2AH_2 + O_2$$

Little doubt now remains that photolysis of water in the Hill reaction with production of reducing power and oxygen represents a partial model of photosynthesis in a cell-free system.

Recently, Arnon, Whatley and Allen[2] have made the important observation that when a phosphate acceptor system (adenosine diphosphate, Mg^{2+} and PO_4^{3-}) is included in the Hill reaction system with coenzyme II or ferricyanide as hydrogen acceptor, oxygen evolution is stoichiometrically related to phosphate esterified into adenosine triphosphate. Moreover, in the ferricyanide reaction the rate of production of oxygen is stimulated two-fold by addition of the phosphate acceptor.

In the present work a similar stimulation of the Hill reaction rate by phosphate acceptors has been

observed with coenzyme II as hydrogen acceptor. The reduction of substrate amounts of pyridine nucleotides by catalytic amounts of chlorophyll has been shown to require a protein factor readily extractable from chloroplasts[3,4]. A preparation of this factor was obtained from spinach leaves by the method of San Pietro and Lang[4]. Chloroplasts were obtained by grinding spinach leaves in 0·4 *M* sucrose containing 0·05 *M tris* buffer *p*H 7·8 and 0·01 *M* sodium chloride. The fraction sedimenting between 500 and 1,500*g* was resuspended in the same medium. Reduction of added pyridine nucleotide was followed by observing the increase in optical density at 340 mμ after a period of illumination. The blank cell contained all the reagents except pyridine nucleotide. Fig. 1 shows that the reduction of coenzyme II is stimulated 2·5-fold by the presence of the phosphate acceptor system and that all the components of this system are necessary for appreciable stimulation. In these experiments, contrary to the findings of San Pietro and Lang[4], coenzyme I was not reduced either in presence or absence of the phosphate acceptor.

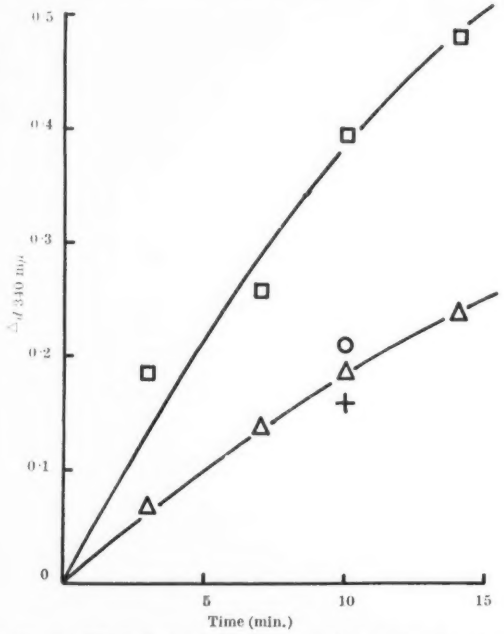

Fig. 1. Effect of phosphate acceptor system on the rate of reduction of coenzyme II by isolated chloroplasts. The reaction mixture contained, in a final volume of 2·5 ml., leaf protein 0·26 mgm., chloroplasts containing 23 μgm. chlorophyll and (except where otherwise indicated) the following in micromoles: *tris* buffer, *p*H 7·4, 80; coenzyme II, 0·5; adenosine diphosphate, 2; magnesium chloride, 10; phosphate buffer, *p*H 7·4, 80. Illumination by 500-watt projector lamp at 1 ft. temp. 16°. □, complete system; ○, magnesium omitted; +, adenosine diphosphate and magnesium omitted; Δ, adenosine diphosphate, magnesium and phosphate omitted

Arnon *et al.*[3] in their observations on phosphorylation accompanying coenzyme II reduction by illuminated chloroplasts have shown that addition of catalytic amounts of flavin mononucleotide or menadione abolish both oxygen evolution and the accumulation of reduced coenzyme II and stimulate phosphorylation. A probable mechanism for this effect suggested itself in the course of the present work. All the leaf and chloroplast protein fractions active in mediating coenzyme II reduction were

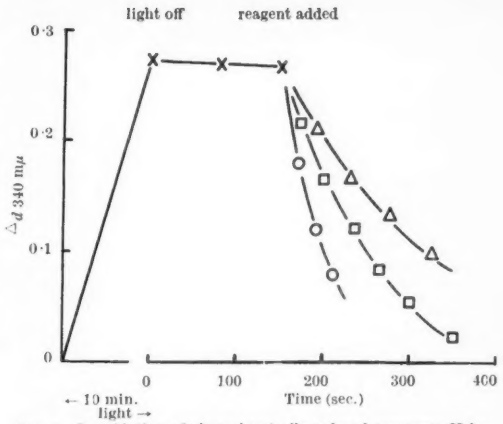

Fig. 2. Reoxidation of photochemically reduced coenzyme II by some catalysts of photophosphorylation. Reaction mixture as Fig. 1 (complete system). At the time indicated 0·05 μmole of the following added: △, flavin mononucleotide; □, pyocyanine; ○, menadione

found also to possess a very active coenzyme II diaphorase activity similar to that reported by Avron and Jagendorf[5]. Diaphorase in the presence of a rapidly autoxidizable hydrogen acceptor should function as a reduced pyridine nucleotide oxidase. Menadione and flavin mononucleotide are listed by Avron and Jagendorf as hydrogen acceptors for their coenzyme II diaphorase from chloroplasts. Their effect in reoxidizing reduced coenzyme II produced photochemically by a chloroplast system containing San Pietro and Lang leaf extract is shown in Fig. 2. Here also pyocyanine is shown to have a similar

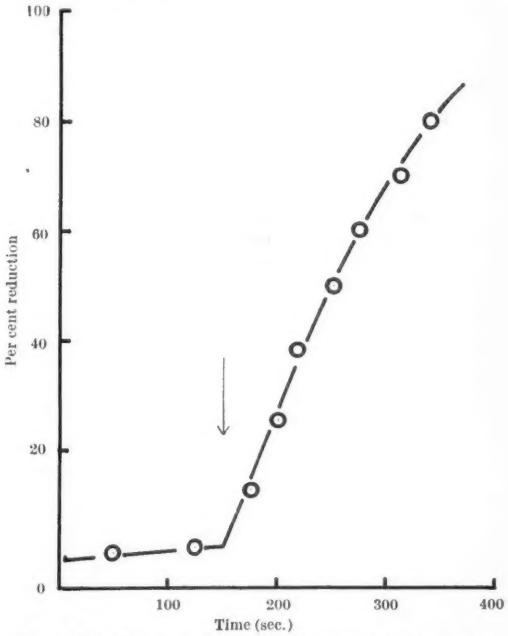

Fig. 3. Catalytic effect of pyocyanine in promoting reduction of methæmoglobin by illuminated chloroplasts. Reaction mixture contained chloroplasts equivalent to 35 μgm. chlorophyll; whale muscle methæmoglobin, 0·35 μmole; phosphate buffer, *p*H 7·4, 150 μmoles and water to 5 ml. Pyocyanine (0·05 μmole) added at time indicated by arrow. Illumination by 500-watt projector lamp at 1 ft., temp. 18°

activity. Pyocyanine has been found by Walker and Hill[6] to resemble flavin mononucleotide and menadione as an active catalyst of photophosphorylation. It has not previously been recorded as an autoxidizable hydrogen acceptor of the chloroplast diaphorase.

These observations suggest that these photophosphorylation catalysts may function by maintaining a level of oxidized coenzyme II in competition with the light-driven reduction of the coenzyme. In the intact leaf this level would be maintained by utilization of the reduced coenzyme in carbon dioxide fixation. An objection to the concept is that the catalysts stimulate phosphorylation by chloroplasts in the absence of added coenzyme II and leaf extract. It has, however, been shown that isolated chloroplasts contain significant amounts of pyridine nucleotides[7]. Moreover, in the present work it was found that both the diaphorase and pyridine nucleotide reductase activities remained in association with the chloroplasts isolated in isotonic media. Such chloroplasts in conjunction with pyocyanine do in fact bring about re-oxidation of reduced coenzyme II in the absence of added leaf extract.

A necessary condition for a mechanism of this kind to function is that the photophosphorylation catalysts should be shown to be reduced by illuminated chloroplasts. This was demonstrated indirectly by using the catalysts to couple the reducing power of illuminated chloroplasts to the reduction of methæmoglobin. Methæmoglobin is not reduced directly by isolated chloroplasts[8]. Fig. 3 shows that addition of a catalytic amount of pyocyanine to the system results in a rapid reduction of the hæm-protein. It thus appears that the pyocyanine can act as a hydrogen acceptor in the Hill reaction, but in the absence of a further reduction step is rapidly reoxidized by free oxygen or its precursors in the system. Similar results were obtained with flavin mononucleotide and menadione.

The experimental details of this work will be published more fully elsewhere.

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STRUCTURE OF α-HYDROXYACETYLENE COMPLEXES OF PLATINUM(II)

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THE best characterized co-ordination compounds containing olefinic hydrocarbons as ligands are those of platinum(II). They were discovered in 1830[1]. Nevertheless, corresponding complexes of acetylenic hydrocarbons have proved somewhat difficult to obtain, and their preparation has been reported only recently[2,3]. Our study[3] showed that the stability of the complexes depends critically upon the structure of the acetylenic hydrocarbon, $R.C{\equiv}C.R'$. It appeared that the more electronegative and conjugative the nature of the hydrocarbon radicals R and R' the lower the stability of the complexes. It is therefore surprising that complexes of the dihydroxyacetylene, $Me_2C(OH).C{\equiv}C.C(OH)Me_2$ (*ac*), with strongly electronegative hydroxyl groups attached to the α-carbon atoms, should form relatively very stable complexes of the types K[*ac*$PtCl_3$], *cis*-[*ac*,NH_3PtCl_2] and *trans*-[*ac*,amine$PtCl_2$][4], and so we have prepared a series of complexes of α-hydroxyacetylenes and their methyl ethers, compared their stabilities, and examined their infra-red spectra to see whether the hydroxyl groups contribute in some direct way to the stability of the complexes.

The hydroxyacetylenes form complexes of the type K[*ac*$PtCl_3$] by direct reaction with aqueous K_2PtCl_4 or with $K[C_2H_4PtCl_3]$ in acetone, but up to the present it has not been possible to prepare from these the non-ionic bridged complexes $(ac)_2Pt_2Cl_4$. On the other hand, the acetylenic hydrocarbons form the bridged complexes directly, and the salts of the type K[*ac*$PtCl_3$] are usually unstable in water, eliminating potassium chloride and reverting to the bridged complex. The methyl ethers form considerably less stable complexes than do the hydroxyacetylenes.

In Table 1 we list a representative selection of the complexes of hydroxyacetylenes and their methyl ethers, with pertinent infra-red spectral data.

In these complexes the triple bond is co-ordinated to the metal as shown by the lowering of some 200 cm.$^{-1}$ in the triple bond stretching frequency ($\nu_{C{\equiv}C}$). This should be compared with the lowering of 150 cm.$^{-1}$ observed in the corresponding olefin complexes[5]. It is interesting, too, that the hydroxyl groups are also profoundly modified when the hydroxyacetylenes form complexes, the O—H stretching frequency ($\nu_{O\text{-}H}$) being lowered by 110–140 cm.$^{-1}$, depending on the substituent on the α-carbon atom. This fact, and a number of supporting observations which cannot all be presented here, lead us to suggest that the electron pairs on the oxygen atoms in the hydroxy-

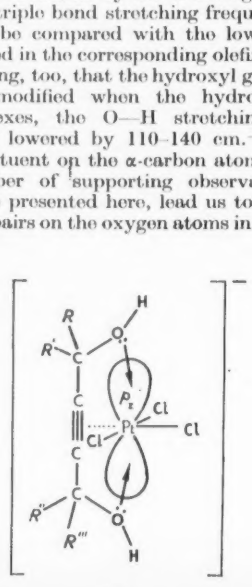

Fig. 1

Table 1. INFRA-RED DATA RELATING TO COMPLEXES OF HYDROXYACETYLENES WITH PLATINUM(II) AT 20° C.

Hydroxyacetylene (*ac*)			Complexes				
			K[*ac*$PtCl_3$]	*trans*-[*ac*,*pip*$PtCl_3$]‡			
Formula	$\nu_{C\equiv C}$* (cm.$^{-1}$)	ν_{O-H}† (cm.$^{-1}$)	$\nu_{C\equiv C}$* (cm.$^{-1}$)	m.p. °C. (dec.)	$\nu_{C\equiv C}$* (cm.$^{-1}$)	ν_{O-H}† (cm.$^{-1}$)	ν_{N-H}† (cm.$^{-1}$)
$Me_2C(OH).C\equiv C.C(OH).Me_2$	2,248§ 2,224	3,612	2,010	112–114	2,045	3,502	3,229
$Me_2C(OH).C\equiv C.C(OMe)Me_2$	••	3,610	2,004	‡‡		3,495	3,221
$Me_2C(OMe).C\equiv C.C(OMe)Me_2$	••	—	1,994	77–79	2,032	—	3,216
$Me_2C(OH).C\equiv C.C(OH)MePh$	••	3,606	2,004	115–118	2,026	3,478	3,224
$Bu^t.C\equiv C.C(OH).Me_2$	2,228††	3,612	2,008	83–86	2,046	3,500	3,223
$Bu^t.C\equiv C.C(OH).MePh$	2,259 2,224	3,601	2,009	107–109·5	2,041	3,475	3,224

* Measured in 'Nujol' mulls at 20° C. $\nu(C\equiv C)$ stretching gives only weak bands in the infra-red spectrum and the above assignment must be regarded as tentative. † Measured in carbon tetrachloride at 20° C. ‡ *pip* = piperidine. § Raman spectrum; see ref. 10. •• Not visible. †† Liquid film. ‡‡ Viscous oil which did not crystallize.

and methoxy-acetylenes interact with the vacant $6p_z$-orbital of the platinum atom as shown in Fig. 1. Alternatively, in the case of the hydroxyacetylenes, the hydrogen atoms of the hydroxyl groups may interact with electrons in the $5d_{z^2}$-orbital of the metal. Thus the unexpected stability of the complexes would arise because the hydroxyacetylenes behave as multidentate ligands, and the platinum(II) atom has a very distorted octahedral configuration such as has been demonstrated[6] in certain complexes of the type $[o\text{-}C_6H_4(AsMe_2)_2]_2PtI_2$.

Intermolecular hydrogen bonding between the hydroxyl groups, or a hydroxyl group and a chlorine atom, is rejected as the cause of the lowering in the O—H stretching frequency, because there are no bands which can be assigned to free hydroxyl groups in the spectra of carbon tetrachloride solutions of the complexes, and the spectra of the solutions are unchanged on addition of dioxane. Intramolecular hydrogen bonding between the hydroxyl groups and the chlorine atoms is sterically impossible if the triple bond lies perpendicular to the plane of the platinum and chlorine atoms, as does the double bond in the olefin complexes[7,8]. In alkyne complexes of the type *trans*-[$Bu^t.C\equiv C.R$,piperidine$PtCl_2$], the N—H stretching frequency (ν_{N-H}) is independent of the group R in the alkyne, having a value[9] of 3,221 cm.$^{-1}$. In the hydroxyacetylene complexes it changes considerably as substitution about the α-carbon atom is changed, and especially on methylation of the hydroxyl groups. This suggests that there is a route from the N—H bond to the place of substitution other than through the triple bond. On the other hand, the N—H frequency (3,228 cm.$^{-1}$) of the corresponding allyl alcohol complex, in which the hydroxyl group would not be expected to interact with the $6p_z$- or $5d_{z^2}$-orbital for steric reasons, is identical with that of the corresponding complex of allyl methyl ether.

The stability of the dihydroxyacetylene complexes is highly dependent on the structure of the glycol, $RR'C(OH).C\equiv C.C(OH)R''R'''$. When $R = R' = R'' = R''' = Me$, stable complexes, Na[*ac*$PtCl_3$] and K[*ac*$PtCl_3$], are readily formed, but the introduction of even one hydrogen atom (R = H, $R' = R'' = R''' = Me$) leads to the production of unstable gums, presumably[9] due to oxidation of the —CH(OH)— group to C=O. Complexes of acetylenic glycols containing one or two phenyl groups (for example, $R = R'' = Ph$, $R' = R''' = Me$) are less stable and have been isolated as potassium salts but not as sodium salts. Hydroxyacetylenes with phenyl groups conjugated to the triple bond, for example, $Ph.C\equiv C.C(OH)Me_2$ and *o*-$HO.C_6H_4.C\equiv C.C_6H_4.OH$-*o* and the diyne diol $Me_2C(OH).C\equiv C.C\equiv C.C(OH)Me_2$, also give unstable complexes, which we have not been able to isolate as sodium or potassium salts, but which might be isolated as salts of larger cations[3]. Again it appears that absence of conjugation and a high positive inductive effect of the substituent groups favour the formation of stable complexes.

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HETEROSIS AND THE GENETICS OF COMPLEX CHARACTERS

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HETEROSIS is one of a group of phenomena for which an adequate genetic interpretation has not emerged. The group comprises inbreeding depression, hybrid stability or homœostasis, general and specific combining ability, as well as hybrid vigour in its broadest sense. In discussing the role of inbreeding and the superior yield of hybrids, Fisher[1] concluded that the removal of deleterious recessives as a result of inbreeding could account for not more than 1 per cent of the improvement in yield in hybrids, and that increases of the order of 20 per cent remained to be explained. Interpretations based on the super-

iority of the heterozygote or 'over-dominance'[2] have not proved entirely acceptable because whenever over-dominance has been investigated using genetic markers, it has not been found generally to occur[3]. In the absence of a clear-cut unifying hypothesis, present-day concepts of heterosis have become surrounded by highly sophisticated escape clauses involving all the known intricacies of gene action.

Heterosis and its allied expressions are properties of quantitative characters, particularly of such characters as yield, stature, viability and reproductive efficiency. That all expressions of this kind are complex interactions between simpler growth processes is immediately obvious, and this common denominator of quantitative characters is frequently referred to in discussions on heterosis. Nevertheless, the implications inherent in the absence of a direct relationship between gene and complex phenotypic expressions are seldom recognized in interpretation.

In one of the first attempts at explaining hybrid vigour, Keeble and Pellew[4] suggested that the inheritance of height in peas could be explained on the basis of two complementary loci each possessing one dominant and one recessive allele. Excess height in the hybrid resulted from the complementarity of dominant alleles from opposite parents; one conditioning length of internode and the other thickness of stem. (Although in certain circumstances thickness of stem may contribute to stature in plants, it should be noted that the components mostly directly concerned with height are internode length and internode number. This, however, does not affect the principles revealed by the work.) The genetic interpretation advanced by Keeble and Pellew achieved meaning and simplicity only because of the recognition that stature as a measurable character was not a primary expression of gene function, but resulted from multiplicative interaction on the phenotypic level between components which segregated in a manner suggesting direct genic control. The components of height in this material were not heterotic, and nothing more complicated than dominance was necessary to provide an adequate genetic explanation of the results. This early model of the behaviour of heterotic characters, although widely quoted as a special case, has not been fully explored and understood in later work. Hagberg[5,6], although recognizing a similar system in data on *Galeopsis* under the term 'combination heterosis', considered it could be different from 'transgressive heterosis' in which the hybrid is superior in one or more of the components of growth. In this connexion he neglected the most important aspect underlying Keeble and Pellew's interpretation, namely, that height in the pea remained genetically transgressive only so long as the components of height remained unidentified. The complexity of quantitative characters generally is such that the resolution of ultimate cell processes is a matter of utmost difficulty. In these circumstances, therefore, it is more rational to suspect the unitary nature of the component characters than to attribute hypothetical properties to the genetic system when departures from a complementary model are encountered.

Recent evidence from a study of inheritance of yield in the tomato has indicated that systems basically similar to the model governing height in the pea may be of common occurrence. It seemed, therefore, desirable to inquire how far the large body of experimental fact available concerning heterosis and allied phenomena fits in with a simple genetic system when due weight is given to interactions on the phenotypic level between the components of complex expressions.

Heterosis for Yield in the Tomato

The five characters—number of flowers, date of first flower, average weight of fruit, number of fruit and yield of fruit—were studied in three F_1 hybrids. The parents and their F_1 hybrids were compared using means of thirty replicates set out in randomized blocks.

None of the hybrids exceeded the better parent in any of the characters with the exception of yield per plant. Yield in all three hybrids exceeded the highest yielding parent. Yield when measured as weight is a product of number and weight of fruit, and in two of the hybrids number of fruit equalled the 'mid-parent' while the average weight of fruit was slightly in excess of this value. The third hybrid inherited phenotypic dominance for a high number of fruit from one of its parents but in weight of fruit it was only slightly in excess of the lower parent. Heterosis in the compound character was a product of various levels of expression of the components in the F_1, ranging from dominance of the better parent to a slight excess over the poorer parent. Heterosis, therefore, is clearly a property of the phenotype, and is conditioned by the nature of the association between the unit characters in the parents. When two parents differ reciprocally for two interacting components, and if the F_1-levels compensate one another in such a way that their product is greater than in the parent, heterosis is inevitable. Table 1 gives a simple example showing the consequence of mating reciprocally different parents.

Table 1

	Component *A* fruit number	Component *B* fruit weight	Yield
Parent *X*	3	1	3
F_1 (heterosis for yield)	2	2	4
Parent *Y*	1	3	3

The genetic system in the above model is one of blending inheritance, and it is difficult and unnecessary to envisage the operation of the remotest form of interaction on the genetic level. The genes or gene products controlling average weight and number of fruit need not and probably do not interact in the sense that an enzyme and a precursor might interact in a synthesis. Complex characters such as yield can be based on units of the genetic system which act completely independently of one another. Interaction occurs on a higher level of organization, among the components of the phenotype. Thus to interpret hybrid vigour in terms only of gene interaction is a basic misconception which has contributed greatly to the present confused state of the subject.

The system described in the tomato has wider application as can be seen from investigations on the inheritance of yield in wheat[7]. Yield of grain and the component characters weight per grain, grain per spikelet, spikelets per ear, ears per plant, were studied in all possible crosses between four varieties. None of the components showed heterosis, and their levels in

F_1 hybrids were on average slightly in excess of the 'mid-parent'. Owing to the small number of comparisons possible in a 4 × 4 diallel cross, one cannot determine with any degree of certainty whether the excess was real. Grain yield in all crosses was heterotic; the average yield of the parents and F_1 families was 31·9 ± 0·76 and 37·7 ± 1·02 respectively. The authors interpreted this behaviour as being the result of multiplicative as distinct from additive gene action, and concluded: "it can be said with confidence that gene interaction plays a part in determining the control of this character". It now seems doubtful whether an interpretation based exclusively on genetic considerations was entirely justified.

Detailed examination of the individual wheat crosses shows that all six parental combinations possessed varying patterns of inequality such as was described for the tomato hybrids. Four of the six were reciprocally different for all four components. Since the component-levels in the hybrids were close to, or slightly in excess of, the 'mid-parent', heterosis for grain yield was inevitable. In wheat, as in the tomato, an essentially additive genetic system conditions a multiplicative somatic basis to yield which, when analysed as a simple character, leads erroneously to a non-additive genetic interpretation.

In a further study on heterosis among 153 hybrids in a diallel cross of 18 inbred lines of the tomato[8], further aspects of heterosis have been revealed which are relevant to this discussion. First, in certain crosses heterosis has been found for yield components such as number of fruit, and this is interpreted as evidence that the component itself may be a produet of sub-units. Secondly, heterosis for both yield and its components was expressed only in hybrids between the poorer parents. Hybrids involving the best parents were inferior to the high parent in the crosses. The best varieties possess optimal levels in the yield components whereby maximal yields are achieved. The highest levels of yield in the tomato can be expressed in homozygotes. There is therefore no advantage for an inbreeding species such as the tomato in heterozygosity *per se*. Thirdly, the components, number and weight of fruit, are negatively correlated; $r = -0{\cdot}66$ ($n = 18$) and $-0{\cdot}70$ ($n = 153$) in the parents and hybrids respectively. This implies that in the course of the production of a certain finite weight of fruit, a variety producing large numbers will have small fruit and vice versa. The maximal level at which each single component can function separately is far in excess of what can be achieved by their product. The phenotype cannot sustain the production capacity that potentially resides in the multiplicative relationships between maxima at each of the unitary divisions of a complex expression. When the limits for the respective functions are pushed too far by selection, or by inbreeding in outbreeders, a physiological breakdown occurs. This frequently expresses itself as sterility, reduced viability or susceptibility to disease[9–11], and may be the basis of concepts of physiological limits[12].

Heterosis and Inbreeding Depression

Inbreeding is invariably associated with loss of vigour in cross-fertilizing species. The commonly accepted explanation for this behaviour is based on the dominance hypothesis, and on the segregation of homozygous genotypes. The extent of the average depression in a randomly breeding population where there is no selection depends only on the relative difference in expression between the segregating dominant and recessive alleles. A genetic system which is strictly additive in expression cannot account for average inbreeding depression because, in the absence of selection, gene frequencies remain unchanged and the mean of the inbred population is therefore unaltered. This appears at first sight to exclude the possibility of commonly occurring systems such as were described for tomato and wheat being concerned in inbreeding depression.

The dominance hypothesis, despite the fit to average values of inbreeding, presents to my mind one unattractive feature. Correspondence between experimental evidence and the dominance hypothesis centres around progeny averages, and the drop in vigour is related to the frequency of the homozygous recessive which after about five generations of selfing will be approaching the limit of $\frac{1}{2}$ at each locus. The homozygous dominant will also have the same frequency, and for n loci the frequency will be $(\frac{1}{2})^n$. The failure in practice to isolate vigorous homozygous dominants has, on the dominance hypothesis, been attributed to the size of n and to linkage. A purely mechanistic explanation of this kind is not entirely acceptable for the interpretation of a vital process. Furthermore, in view of the thousands of inbred lines that have by now been studied in maize, it is inconceivable that chance recombinants of near maximal expression would not have appeared if the cause was one merely of permutation. It must also be noted in this connexion that the chance of isolating recombinants will depend not on the potential n, but on that portion which is heterozygous. In crop plants such as maize in which some form of selection for vigour has been practised for centuries, the number of unfixed loci may be fewer than is generally assumed in attempts to make the dominance hypothesis acceptable. It may be prudent, therefore, to explore other possible factors of causality.

The negative correlation between the components of complex expressions and the concept of physiological limit may provide the missing factor necessary to explain inbreeding depression in terms of additive genetic factors. Selection experiments already mentioned clearly indicate the undesirable consequences of extremes of selection and of genetic fixation above the optimal level for fitness. In terms of the components of fitness, physiological breakdown means that the tolerance-level of the product of component interaction has been exceeded. Too many components are simultaneously at too high a level. A proportion of the genotypes following inbreeding of heterozygotes should also show loss of fitness similar to that resulting from intense selection. Multiple homozygotes for hypermorphic alleles segregating after inbreeding represent genotypes where all the components are simultaneously at a high level, and might be expected to belong to a class where fitness is severely reduced. They are the equivalent of a highly selected, closed population where sterility, susceptibility to disease or other forms of debilitation are reducing fitness.

The elimination of dominants has been demonstrated by Fisher[13] in populations of *Paratettix texanus* in which it was estimated that double dominants were eliminated to the extent of not less than 40 per cent in each generation. The mechanism underlying this selective elimination of genotypes is almost certainly physiological and corresponds very closely

to the system postulated here to account for inbreeding depression.

If, as seems likely from the above considerations, 'compounds' of dominants or of hypermorphic alleles are to a greater or lesser degree self-eliminating in outbreeders, the dominance hypothesis is not the only explanation for inbreeding depression. The pattern fits additive gene action equally well.

A distinction, therefore, has to be made between gene interaction and the interrelations of the component parts of the phenotype. Phenotypic characters may be multiplicative and may consequently show a mutually dependent relationship while the gene system is strictly additive and its units are strictly independent in function. Heterosis in complex characters has been shown here to occur in hybrids simply as a result of a reciprocal inequality of independent gene action in the parents. Given reciprocal inequality in the levels of component characters in the parents, intermediate levels in hybrids inevitably lead to heterosis in the complex character. It appears, therefore, that many of the difficulties that are encountered in the interpretation of heterosis arise out of the failure to recognize the component parts of complex expressions.

Multiplicative interaction between adjusted levels of component characters may govern the control of the physiological limit, as is indicated by negative correlations between components of yield in the tomato. It is suggested that mal-adjusted, maximal levels of expression in sub-characters may be responsible for inbreeding depression in outbreeding species leading to the self-elimination of genotypes homozygous for several dominant or hypermorphic alleles. Inbreeding depression, like heterosis, may therefore be explained simply on the basis of interactions on the somatic level which are controlled by a complementary, essentially additive genetic system.

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TURNIP YELLOW MOSAIC VIRUS NUCLEOPROTEIN PARTICLES WITH DIFFERING BIOLOGICAL AND PHYSICAL PROPERTIES

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PREVIOUS work[1] has shown that purified preparations of turnip yellow mosaic virus contain two types of particle. One is a nucleoprotein containing 37 per cent of ribonucleic acid within a roughly spherical shell of protein. The other is an apparently identical protein containing no ribonucleic acid. The nucleoprotein is infectious while the protein is not. The ratio of nucleoprotein to protein particles in the preparations is close to 2 : 1[1,2]. The sedimentation patterns obtained in the ultracentrifuge with both these components give no indication of inhomogeneity[1,3].

The value of density gradient centrifugation under equilibrium conditions in strong cæsium chloride solutions for the fractionation of macromolecules has recently been demonstrated[4,5].

We have now found, using sedimentation into dense cæsium chloride solutions under non-equilibrium conditions, that the nucleoprotein particles of turnip yellow mosaic virus fall into at least two classes with respect to density and infectivity.

Turnip yellow mosaic virus was isolated from infected chinese cabbage plants by the ammonium sulphate procedure[1] or by differential centrifugation. Preliminary tests with whole virus preparations showed that incubation with strong cæsium chloride solutions for 2 hr. at room temperature, followed by 14 hr. at 4°, had no detectable effect on the infectivity of the virus. To avoid anomalous effects due to crystallization or precipitation of the virus at room temperature in the strong salt solutions employed during sedimentation, all manipulations were carried out at temperatures between 4° and 10° C.

In the sedimentation experiments 1–10 mgm. of a virus preparation in solution in 0·1–0·6 ml. water was layered over 3·5 ml. of cæsium chloride solution (density = 1·39–1·43) in a 'Lusteroid' tube. The samples were then centrifuged for 200–240 min. at 32,000 r.p.m. in the Spinco model *L* preparative ultracentrifuge using the No. 39*S* rotor. Under these conditions the virus protein component stays in the boundary between the water layer and the cæsium chloride solution. The nucleoprotein sediments through the salt solution and resolves into bands which can be located visually by scattered light (Fig. 1).

The various components were withdrawn by piercing the wall of the tube with the needle of a hypodermic syringe, and dialysed to remove salt. The bands cannot be removed quantitatively by this procedure, but other methods we have tested lead to substantial mixing of closely spaced bands. Estimates of relative amounts of material in various bands were based on the ultra-violet absorption curves of the extracted samples. Such estimates on duplicate pairs of bands varied by as much as 25 per cent.

In preparations of virus made by the ammonium sulphate procedure, two sedimenting bands appear. The faster-sedimenting band (B_2) usually contains 1/5–1/20 as much material as the slower band (B_1). If these two bands are removed and the material from several tubes combined and run again, each band shows a slight contamination with the other on the second run. A third sedimentation usually gives material with no observable contamination. This result suggests that the bands are not produced by the action of cæsium chloride on a uniform population of particles. Both bands give typical virus nucleoprotein spectra, and the nitrogen/phosphorus ratios suggest that both types of particle have the same

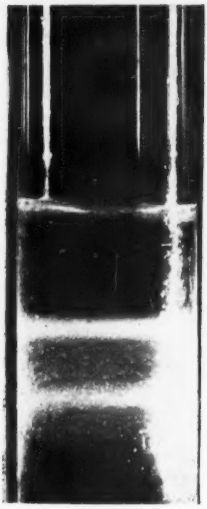

Fig. 1. Fractionation of turnip yellow mosaic virus nucleoprotein in a dense cæsium chloride solution. Of the two nucleoprotein bands appearing in the photograph, the upper (B_1) is infectious, while the lower (B_2) is non-infectious. 4 mgm. of a virus preparation in 0·15 ml. of water was layered over 3·5 ml. of a cæsium chloride solution (density = 1·41). The tube was photographed after 220 min. centrifugation at 32,000 r.p.m. in the Spinco No. 39S rotor

content of ribonucleic acid. Solutions of the B_1 and B_2 components equalized with respect to optical density at 260 mμ were tested for infectivity by inoculation to half-leaves of chinese cabbage. The infectivity of the B_2 component compared with B_1 from once-sedimented bands ranged in different experiments from 25 to 6 per cent.

On three times sedimented bands the B_2 material had only 3 per cent the infectivity of B_1. Thus the B_2 band is very probably completely non-infectious. However, to test the possibility that B_1 and B_2 were two different strains of the virus of differing infectivity multiplying together in the plant, four single-lesion isolates were made from plants infected with virus from each band. The isolates were multiplied in chinese cabbage. No symptom differences were observed. Virus isolated by an initial high-speed centrifugation followed by one ammonium sulphate precipitation from each isolate gave a similar band pattern in all cases. The B_2 band was present in about 1/20 the amount of the B_1 band. That virus strains were not involved was confirmed by the production of the B_1 and B_2 bands from a 'necrotic' strain of the virus which is biologically distinct from the type strain.

The B_1 and B_2 bands appear in similar proportions in virus prepared from the same plant material, either by the alcohol–ammonium sulphate procedure, or by differential centrifugation alone. It therefore seems unlikely that either of these bands is an artefact of the procedure used to isolate the virus.

However, in virus material isolated by centrifugation only, a third more slowly moving band (B_0) appears following sedimentation in cæsium chloride. This band is not visible in most ammonium sulphate preparations, and can be largely removed from virus prepared by centrifugation by one ammonium sulphate precipitation. The fact that band B_0 sediments into a cæsium chloride solution of $D = 1{\cdot}40$ suggests that it must contain some ribonucleic acid. The ultra-violet absorption spectrum and the nitrogen/phosphorus ratio show that the material in the B_0 band contains a lower proportion of ribonucleic acid than the B_1 component and its infectivity is substantially less. However, the B_0 material has not yet been obtained sufficiently free from contamination with B_1 for definitive chemical analysis or infectivity tests.

A detailed study of the serological behaviour of these nucleoprotein components has not yet been made. However, all three give similar virus precipitation end-points (based on the optical density of the solution at 260 mμ) when tested with an antiserum prepared against unfractionated turnip yellow mosaic virus.

The experiments described above suggest that these nucleoprotein components are not artefacts of the purification or isolation procedures, although it may be very difficult to prove beyond doubt that they exist as such in the plant. The ability to fractionate a virus nucleoprotein preparation into infectious and non-infectious classes of particle should be useful for more detailed studies on the inactivation of the virus by various agents. The fact that turnip yellow mosaic virus nucleoprotein as usually prepared is not homogeneous may be particularly relevant for structural studies on the virus, for example, for end-group assays on the ribonucleic acid, where homogeneity of the starting material is an essential prerequisite.

This work was supported in part by a grant from the Rockefeller Foundation.

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NITRATE REDUCTION BY AQUEOUS EXTRACTS OF EXCISED TOMATO ROOTS

By C. S. VAIDYANATHAN and Prof. H. E. STREET
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EXCISED tomato roots are normally supplied their nitrogen as nitrate (45 mgm. N/l.) in a medium of *p*H 4·5–4·8[1]. By substituting ferric ethylenediamine tetraacetate for the ferric sulphate of White's medium, active growth in nitrate occurs over the *p*H-range 4·0–7·2 and in ammonium (4·5 mgm. N/l.) at *p*H 6·8 or above[2]. Nitrite (7·0 mgm. N/l.) at *p*H 6·0–6·8 and glutamine (4·8 mgm. N/l.) at *p*H 6·8 can also function as nitrogen sources for root growth. A preliminary study has now been made of

the nitrate-reducing activity of aqueous extracts from excised tomato roots (Best-of-All) grown with these different nitrogen sources and in presence of 0·001 p.p.m. molybdenum.

The extracts were prepared by grinding the fresh roots with three volumes of water at 4° C. followed by centrifuging at this temperature for 15 min at 600*g*. 1 ml. of this supernatant was added to 3 ml. buffer and the completed reaction mixture adjusted to 5 ml. and incubated at 20° C.

Nitrite was determined by the sulphanilamide-N-(1-naphthyl)-ethylenediamine hydrochloride method[3], hydroxylamine and hyponitrite by the Czaky modification of Blom's procedure[4] and ammonia by the Conway microdiffusion technique in conjunction with the phenol–hypochlorite method[5]. The formation of nitrite from nitrate could be studied since nitrate reduction was not stimulated by addition of manganese whereas reduction beyond nitrite proceeded only very slowly in its absence.

Extracts from nitrate-grown roots, in presence of 0·2 *M* orthophosphate buffer (*p*H 7·0), did not reduce nitrate (50 μmoles potassium nitrate) to nitrite in absence of added co-factors or in presence of combinations of molybdenum (0·1 μmole), reduced diphosphopyridine nucleotide (0·3 μmole) and flavin mononucleotide (0·5 μmole). However, the further addition of aldehyde-free ethanol (3·5 m.moles), lactate (0·35 m.mole), succinate (3·0 μmoles) or glutamate (1·5 μmoles) led to the formation of 5–7 mμmoles nitrite in 3 hr. The necessity for these additions and the fact that a further small enhancement of nitrite formation followed the simultaneous addition of 0·8 μmole nicotinamide[7] suggest the presence in the root extracts of a diphosphopyridine nucleotide oxidase[6]. By contrast, similarly prepared extracts from 15-day-old tomato seedlings showed the nitrate reductase activity (5·3 mμmoles nitrite/3 hr.) without the addition of any dehydrogenase substrate.

The formation of nitrite by the extract of excised roots in the presence of molybdenum, diphosphopyridine nucleotide, flavin mononucleotide and ethanol began to deviate from linearity within 2 hr. although the nitrite content continued to increase for at least 10 hr. Activity could be detected over the *p*H range 5·7–8·0 with optimum activity at *p*H 6·5–7·0[8]. When tested at 10^{-3} *M*, potassium cyanide caused 90 per cent, and copper sulphate 50 per cent, inhibition of activity; diethyldithiocarbamate, *o*-phenanthroline and 8-hydroxyquinoline were inactive as inhibitors at this concentration. 10^{-3} *M* sodium fluoride was slightly stimulatory. Omission of molybdenum caused up to 20 per cent reduction in activity.

Extracts from excised roots grown for 15 days with ammonium or glutamine as nitrogen sources had barely detectable nitrate reductase activity, whereas, in a simultaneous test, extracts from nitrate- and nitrite-grown roots formed 5·2 and 4·5 mμmoles nitrite, respectively, in 2 hr. Similar adaptive formation of the reductase has been reported from work with rice seedlings[9] and wheat embryos[10]. It is an essential part of future work to study this adaptive formation in excised roots over the short time periods which have been used in work with leaf fragments[11].

Verhoeven[12] has emphasized that at least three different types of nitrate-reducing systems are known and therefore, in encountering lack of nitrate reduction by excised root extracts in presence of added molybdenum, diphosphopyridine nucleotide and flavin mononucleotide, we tested a number of other combinations of possible electron donors and activating metals. This led to the detection of an enzymic reduction of nitrate to nitrite for which ascorbic acid and ferrous iron are essential co-factors. Ascorbic acid causes a non-enzymic destruction of nitrite at the high acidity of the sulphanilamide reagent used for the nitrite determination[13]. This was reduced by the presence in the reaction mixture of iron and root extract. Higher values for nitrite were obtained by addition to the reaction mixture of 100 mgm. 'Norit' carbon[14] prior to the nitrite determination, despite the known adsorption of nitrite by this reagent[15].

The standard reaction mixture used in assaying the activity of the ascorbic acid–ferrous iron enzyme system contained, in 5 ml.: 3 ml. 0·2 *M* phosphate buffer (*p*H 7·2), ascorbic acid (1·1 μmoles) ferrous sulphate (0·7 μmole), molybdenum (0·1 μmole), 50 μmoles potassium nitrate and 1 ml. root extract. Root extracts prepared on separate occasions differed in activity; nitrite formation in 2 hr. at 20° C. ranged from 3·5 to 8·1 mμmoles. Omission of molybdenum reduced activity by up to 15 per cent. No activity could be detected with boiled extract or when either iron or ascorbate was omitted, except that ascorbate alone had low activity in presence of 0·3 ml. saturated solution of sodium fluoride, possibly due to fluoride inhibition of the dissimilation of endogenous electron donors[16]. Nitrite formation did not occur in presence of root extract, buffer and homocysteine, but this latter substance alone among those tested significantly enhanced activity in presence of ascorbate (for example, 0·15 μmole homocysteine raised the nitrite production in 2 hr. from 3·7 to 6·5 μmoles).

No results have yet been obtained on which to assess the *in vivo* significance of this ascorbic acid–iron activated system. Study of its activity in reduction below the level of nitrite was precluded by the demonstration that ascorbate + iron caused a non-enzymatic destruction of hydroxylamine without formation of detectable quantities of nitrite or ammonium.

Using a reaction mixture containing diphosphopyridine nucleotide, flavin mononucleotide (or 0·65 μmole glutathione), 1·5 μmole nitrite, 0·1 μmole manganese and 3 ml. 0·2 *M* pyrophosphate buffer (*p*H 7·5) extracts from nitrate- or nitrite-grown roots caused complete disappearance of nitrite in less than 3 hr. Only very low activity occurred in absence of added manganese[17]. Very little or no ammonium formation accompanied disappearance of nitrite, and the main reduction product appeared to be hyponitrite since it could be oxidized back to nitrite by iodine, and hydroxylamine could not be detected by the *o*-phenanthroline method[18]. Extracts prepared from roots grown with ammonium or glutamine as nitrogen sources showed barely detectable nitrite reductase activity.

Extracts from nitrate-grown excised roots formed ammonium from nitrite (1·5 μmoles), hyponitrite[15] (1·0 μmole) or hydroxylamine (4·3 μmoles) when both lactate (0·35 m.mole), succinate (3·0 μmoles) or formate (6·1 μmoles) and nicotinamide (0·8 μmole) were added to the reaction mixture. Only about 30 mμmoles ammonia arose during the complete destruction of the added nitrite. Hyponitrite destruction proceeded slowly and extension of the incubation

period to 10 hr. was required to obtain 20 mμmoles ammonium. Hydroxylamine disappeared completely within the 2 hr. incubation period but only 30–35 per cent of the nitrogen was recovered as ammonium, suggesting the possible formation of oxime-like compounds.

Excised tomato root extracts in presence of added diphosphopyridine nucleotide and flavin mononucleotide can effect reduction of nitrate, nitrite, hyponitrite and hydroxylamine, in agreement with results for *Neurospora crassa*[17,18]. The reduction steps beyond nitrite are activated by manganese. In this chain the hyponitrite reduction step appears to be rate limiting. Roots grown upon ammonium or glutamine have very low nitrate- and nitrite-reducing activities as compared with nitrate- and nitrite-grown roots. A thermo-labile system for which ascorbate and iron are co-factors and which *in vitro* effects nitrate reduction is also present.

Acknowledgment is made to the University College of Swansea for a research fellowship and to the Indian Institute of Science for the leave of absence which enabled one of us (C. S. V.) to participate in this work.

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A NEW APPROACH TO THE DATING OF THE DEAD SEA SCROLLS

By Prof. D. BURTON, M.B.E., J. B. POOLE and Dr. R. REED
Department of Leather Industries, The University, Leeds, 2

SINCE their discovery some twelve years ago, the Dead Sea scrolls have attracted considerable interest for the light they may throw upon historical Judaism and Christianity. The scrolls, mostly written upon materials derived from animal skin, were found in a number of caves at the edge of the Judaean plateau, a dry and largely infertile region about a mile from the western shore of the Dead Sea. The richest collection of manuscripts came from Cave 4, a mere stone's throw from the ruins of a settlement known as Khirbet Qumran.

It was early considered that a connexion might exist between the settlement and the scrolls; thus for a number of seasons archæologists excavated the site[1]. The oldest levels were of Israelite occupation and dated from the eighth–seventh centuries B.C. The major part of the finds, however, pointed to an establishment which was probably built in the reign of John Hyrcanus (135–104 B.C.) and which was elaborated up to 31 B.C., when it is thought to have been abandoned following a severe earthquake in Judaea. The site lay deserted until the time of Herod Archelaus (4 B.C.–A.D. 6), when it was reoccupied by the previous settlers until it was finally destroyed by Roman solders in A.D. 68 during the first Jewish revolt.

Some controversy still surrounds the identification of the settlers, but the majority view[2] is that they were either the Jewish religious sect called the Essenes or another Jewish group having much in common with the Essenes. It is generally believed that the scrolls were the property of the settlers, and thus the archæological datings of the occupation of Qumran constitute criteria for dating the manuscripts.

The large number of scrolls which have been discovered has also enabled palæographers to trace with greater certainty the evolution of Hebrew script and thus, independently, to date the copying of the manuscripts. Briefly, the scrolls cover the period from the late third century B.C. to the second half of the first century A.D., while the manuscripts regarded as peculiar to their owners (for example, the Manual of Discipline) are considered to have first appeared in the middle of the second century B.C. (ref. 3). This latter date corresponds with the time when the Dead Sea community first segregated themselves from their fellow Jews, and also is in substantial agreement with the earliest settlement levels at Qumran. However, these majority views have not been universally accepted, and throughout Del Medico[4] has maintained that no direct connexion between the scrolls and the settlement existed. Del Medico considers that the scroll caves are deposits (*genizoth*) of books either worn out through extensive use or unacceptable in character to the Jewish authorities. If this view is correct, the date of the final abandonment of the settlement obviously could not be used as a guide for dating the scrolls. Independently, Sukenik[5] had come to a similar conclusion. Furthermore, Driver[6], Teicher[7] and Zeitlin[8], while not acepting the *genizoth* hypothesis, all favour dates later by as much as several centuries than those indicated above.

Thus a need still exists for additional methods of dating the scrolls and preferably for those free from the subjective element inherent in the palæographic approach and involving the examination of the chemical and physical nature of the actual scroll materials.

No such dating tests on the scrolls themselves have hitherto been made. Linen from Cave 1 and palm wood from the settlement ruins have been dated by the radioactive carbon technique and gave median dates of A.D. 33, with a standard deviation of 200 years for the linen[9] and of 7 B.C. and A.D. 18, each with a standard deviation of 80 years, for the palm wood samples[10]. However, the exactness of this dating technique for archæological purposes is limited and the method can give at best only general confirmation of dates established by other means[11].

The fact that many of the scrolls are made from animal skins, the major fibrous component of which is collagen, affords the possibility of an independent method of dating by measuring the shrinkage temperature of the fragments. Unpublished work from this laboratory has shown that the scrolls are parchments, made mainly from the skins of sheep and of goats. Parchment is made from animal skins which have been unhaired and then allowed to dry under tension, usually by stretching on a wooden frame. The resulting material is durable and needs no further chemical treatment, though often, for writing purposes, the surface is made smooth by mechanical means. Thus the making of parchment is quite distinct from that of leather, where the unhaired skin (pelt) is stabilized by treating it chemically with a tanning agent. Skins processed as parchment may last for very long periods provided they are kept dry. Indeed, this is the reason why the Dead Sea scrolls are still in existence. Any degenerative changes occurring in the collagen fibres present in dry parchments are thus likely to be due mainly to the passage of time. Moreover, these changes should be reflected in a lowering of the shrinkage temperature of the collagen fibres. Accordingly, the shrinkage temperatures of a number of scroll fragments were compared with those of other parchment-like materials of known age, in an attempt to establish a correlation between age and shrinkage temperature. The materials studied were :

Group *A*. English parchments covering the period 1193–1955 A.D. Supplied by the Public Records Office, the Chapter Library of Canterbury Cathedral, Dr. M. L. Ryder, Wool Industries Research Association, Leeds, 6, and Mr. T. H. Gardner, of Ampthill, Beds.

Group *B*. Parchments from the Wady Murabba'at caves, dating from the second Jewish revolt, A.D. 132–135.

Group *C*. Scroll fragments from Cave 4, Qumran. These and the Murabba'at fragments were supplied by the Department of Antiquities, Hashemite Kingdom of Jordan, and by Mr. J. M. Allegro, University of Manchester.

Group *D*. Egyptian Aramaic letter fragments of the fifth century B.C., supplied by the Bodleian Library, Oxford.

Group *E*. Egyptian raw hide axe-hafting, *c.* 1300 B.C., supplied by the Department of Egyptian Antiquities, British Museum.

The shrinkage temperatures were determined by the method of Borasky and Nutting[12] as slightly modified by Gill[13]. Small samples of the materials were rehydrated for 1 hr. in distilled water and small fibres teased from them, before mounting (between circular cover slips) on the heating stage of the microscope. Heat was applied at a constant rate (2 deg. C./min.) and, so far as possible, fibres of similar size were used. The shrinkage temperature was taken as being that at which the fibre first began to shrink.

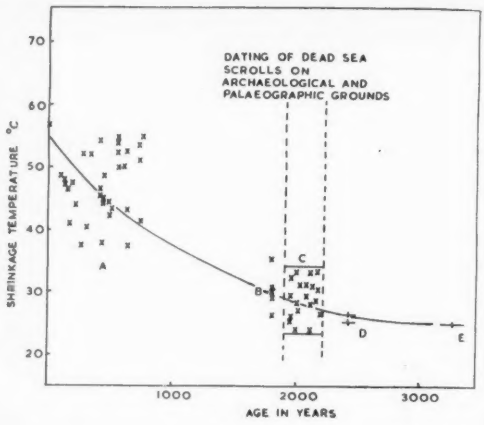

Fig. 1

Usually the mean of three determinations was taken for each material, and the results are shown in Fig. 1.

As regards their shrinkage temperatures, the scroll fragments lie closer to the older samples in groups *B*, *D* and *E* than to the relatively modern parchments (group *A*), which all show higher values. Hence it is likely that the scroll fragments are indeed old and that they are slightly older than the Murabba'at samples, the age of which is well authenticated. Moreover, it is unlikely that the scroll material dates from medieval times, as Zeitlin[8] has suggested. The present findings on the date of the scrolls are thus in general agreement with the assessments based on archæological, palæographic and radioactive-carbon studies. One could be more certain of the usefulness of shrinkage temperature as a guide to age if more parchments older than A.D. 1200 were available for study, but such samples are very difficult to obtain. It should be emphasized that this method of dating necessarily only gives a general guide to the date at which the scroll materials themselves were processed from animal skins. It throws no direct light on the dates at which the scrolls were copied and deposited in the caves.

We wish to thank the Department of Scientific and Industrial Research for providing a special grant for this work ; also those people who have kindly supplied us with the various samples.

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FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, October 12

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "Is the Present Pace of Electrical Progress Good for the Community ?"

SOCIETY OF CHEMICAL INDUSTRY, SURFACE ACTIVITY GROUP (at 14 Belgrave Square, London, S.W.1), at 5.30 p.m.—Dr. Chas. M. Blair: "The Resolution of Petroleum Emulsion".

UNIVERSITY OF LONDON (in the Anatomy Lecture Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. C. D. O'Malley (University of California Medical School): First of three lectures on "Andreas Vesalius—The Development of a Scientist". (Further lectures on October 14 and 15.)*

BEE RESEARCH ASSOCIATION (in the Meeting Room of the Zoological Society of London, Regent's Park, London, N.W.1), at 6.30 p.m.—Dr. F. G. Smith: "Bees and Beekeeping in the Tropics", illustrated by a colour film "Tanganyika Beeswax". 8 p.m.—Prof. G. F. Townsend: "The Activity of Royal Jelly Against Leukaemia and Ascitic Tumours".

ROYAL INSTITUTE OF CHEMISTRY, London Section (joint meeting with the Ewell County Technical College Faraday Society, at the Ewell County Technical College, Reigate Road, Ewell, Surrey), at 7 p.m.—Dr. A. T. James: "Gas Phase Chromatography".

Tuesday, October 13

PHYSICAL SOCIETY, LOW TEMPERATURE GROUP (at the Royal Institution, Albemarle Street, London, W.1), at 4 p.m.—Dr. H. London: "Superfluid Helium" (First Simon Memorial Lecture).

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT AND CONTROL SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Prof. A. Tustin: "The Relationship of Physical Mechanisms to Psychological Processes" (Chairman's Address).

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (joint meeting with the Chemical Engineering Group, at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Mr. G. C. Eddie and Mr. S. Forbes Pearson: "Engineering Aspects of Recent Research Projects in the Preservation of Fish".

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE IN ASSOCIATION WITH GRANADA TV NETWORK (at the Guildhall, London, E.C.2), at 8.30 p.m.—Sir Edward Appleton, F.R.S.: First of the Inaugural Series of The Granada Lectures on the theme of "Communication in the Modern World".

Wednesday, October 14

BRITISH COAL UTILISATION RESEARCH ASSOCIATION (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Sir Eric Rideal, F.R.S.: "Coal—a Colloid and a Chemical" (Eighth Coal Science Lecture).

INSTITUTION OF ELECTRICAL ENGINEERS, EDUCATION DISCUSSION CIRCLE (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "Graduate Training in Industry", opened by Mr. W. H. Taylor.

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. H. Desmond Carter: "The Engineer, Life and Diesel Engines" (Presidential Address).

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. K. H. R. Wright: "Fretting Corrosion".

Thursday, October 15

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (joint meeting with the Iron and Steel Institute, at 14 Belgrave Square, London, S.W.1), at 2 p.m.—Discussion of the 6th Report of the B.I.S.R.A. Corrosion Committee.

INSTITUTION OF MINING AND METALLURGY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. C. R. Metcalfe: "A Botanical Visit to the West Indies"; Dr. Norman K. B. Robson: "Iter Zambesiacum 1958–1959".

INSTITUTION OF ELECTRICAL ENGINEERS, UTILIZATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. T. E. Houghton: "The Electrical Engineer and the Heavy Chemical Industry" (Chairman's Address).

ILLUMINATING ENGINEERING SOCIETY (at the Royal Institution, Albemarle Street, London, W.1), at 6 p.m.—Sir Lawrence Bragg, F.R.S.: "The Nature of Light" (Golden Jubilee Lecture).

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDING MATERIALS GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Dr. E. D. Tingle and Mr. N. Wright: "An Investigation of the Weathering of Road Tar in Open Textured Surfacing"; Dr. J. R. Dewhurst: "An Investigation of the Setting of Road Tar in Surface Dressing".

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Sir William MacArthur, K.C.B., D.S.O.: "The Identification of Some Pestilences of the Past" (Presidential Address).

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

SCIENTIFIC ASSISTANT (with a biological degree, the ability to write correct English, and preferably some knowledge of foreign languages) for work which includes the abstracting and reviewing of biological literature—The Director, Commonwealth Bureau of Plant Breeding and Genetics, School of Agriculture, Cambridge (October 15).

SCIENTIFIC OFFICER (male, with a first- or second-class honours degree in physics or chemistry, and preferably some experience of polymers or biological systems, or ionizing radiation), at the Royal Military College of Science, Shrivenham, Wiltshire, for a two or three years' programme of fundamental research (of an academic character and intended for publication) on effects of high energy radiation on polymers in solutions, and an ASSISTANT EXPERIMENTAL OFFICER or ASSISTANT (Scientific) (with a qualification in physics or chemistry at G.C.E. "A" level, or alternatively some laboratory experience) for work on the same programme—Technical and Scientific Register (K), Ministry of Labour and National Service, 26 King Street, London, S.W.1, quoting A.410/9A (October 19).

GORDON CRAIG FELLOW (graduate in medicine) IN UROLOGY IN THE DEPARTMENT OF SURGERY at the University of Sydney and in THE DEPARTMENT OF UROLOGY at the Royal Prince Alfred Hospital—The Professor of Surgery, The University, Sydney, Australia (October 23).

LECTURER OR ASSISTANT LECTURER IN THE DEPARTMENT OF EDUCATION—The Registrar, The University, Leeds 2 (October 24).

UNIVERSITY TUTOR OR ASSISTANT LECTURER IN MICROBIOLOGY—The Secretary, The Queen's University, Belfast (October 30).

LECTURER OR ASSISTANT LECTURER IN PURE MATHEMATICS—The Registrar, The University, Leeds 2 (October 31).

LECTURER (with an honours degree of a British university and appropriate teaching experience) IN PHILOSOPHY at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, November 6).

LECTURER (preferably with qualifications in stratigraphical and structural geology) IN GEOLOGY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 7).

SCIENTIFIC OFFICER (with a good honours degree, and preferably with postgraduate experience and an interest in soil zoology) IN THE ENTOMOLOGY DEPARTMENT—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (November 14).

SENIOR DEMONSTRATOR (with experience in physical chemistry), and a LABORATORY TECHNICIAN (with experience in physical chemistry) IN THE DEPARTMENT OF CHEMISTRY, University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (November 14).

LECTURER IN PATHOLOGY—The Secretary, The University, Edinburgh (November 15).

LECTURER (preferably with special qualifications in biometry or biochemistry and physiology or mycology and plant pathology) IN BOTANY at the University of Tasmania—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 30).

MYCOLOGIST (with a good honours degree in botany with mycology as a special subject, and a knowledge of the more fundamental aspects of animal and human mycoses), at the Commonwealth Mycological Institute, Kew—The Secretary, Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Bucks (November 30).

SENIOR RESEARCH FELLOW (with a postgraduate degree or research experience in the biochemistry or immunology of parasitic infections) IN IMMUNOLOGY—The Registrar, University of Queensland, St. Lucia, Brisbane, Queensland, Australia (December 1).

ENTOMOLOGIST (with a good honours degree in zoology, with at least two years' postgraduate experience or training in agricultural entomology) IN THE DEPARTMENT OF AGRICULTURE, Nyasaland, to control crop pests—The Department of Recruitment, Colonial Office, London, S.W.1, quoting BCD 63/4/016.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Iron and Steel Institute. Sixth Report of the Corrosion Committee. Compiled by Dr. J. C. Hudson. (Special Report No. 66.) Pp. x+217. (London: Iron and Steel Institute, 1959.) 63*s*. [77

Anti-Locust Bulletin No. 36: Reproduction in the Red Locust (*Nomadacris septemfasciata* Serville) in the Laboratory. By Dr. Maud J. Norris. Pp. ii+46. (London: Anti-Locust Research Centre, 1959.) 7*s*. 6*d*. [77

Relations Between Water and Soil. By T. J. Marshall. (Technical Communication No. 50 of the Commonwealth Bureau of Soils, Harpenden.) Pp. vii+91. (Farnham Royal: Commonwealth Agricultural Bureaux, 1959.) 20*s*. [77

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Greenwich Observations in Astronomy, Magnetism and Meteorology made at the Royal Observatory, Greenwich; the Royal Greenwich Observatory, Herstmonceux; and the Royal Greenwich Observatory, Abinger, in the year 1950, under the direction of Sir Harold Spencer Jones. Pp. xxx+322 (13 plates). (London: H.M. Stationery Office, 1959.) 100*s*. net. [77

Colonial Development Corporation. Annual Report and Statement of Accounts for year to 31.12.58. Pp. v+69. (London: H.M. Stationery Office, 1959.) 4*s*. 6*d*. net. [107

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Army Map Service, Washington. Technical Report No. 24: Statistical and Harmonic Analysis of Gravity. (Project No. MO–011, March, 1959.) Pp. iv+142. (Washington, D.C.: Army Map Service, 6500 Brooks Lane, 1959.) [77

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California Academy of Sciences. Proceedings. Vol. 29, No. 13 (May 29, 1959): From Pipefish to Seahorse—a Study of Phylogenetic Relationships. By Earl S. Herald. Pp. 465–473. Vol. 29, No. 14 (May 29, 1959): A Review of the Snakes of the Genus *Pseudorabdion* with remarks on the status of the Genera *Agrophis* and *Typhlogeophis* (Serpentes: Colubridae). By Alan E. Leviton and Walter C. Brown. Pp. 475–508. Vol. 29, No. 15 (May 29, 1959): Behavior and Reactions of the Pacific Sardine, *Sardinops caerulea* (Girard), Under the Influence of White and Colored Lights and Darkness. By Anatole S. Loukaskin and Norman Grant. Pp. 509–548. Annual Report for the year ending June 30, 1958, with a condensed Report for the years since 1954. Pp. 48. (San Francisco: California Academy of Sciences, 1959.) [77

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Ghana. Annual Report of the Forestry Department for the Calendar year 1957. Pp. iv+43. (Accra: Government Printer; London: Crown Agents for Oversea Governments and Administrations, 1959.) 5*s*. [77

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United States Department of the Interior: Geological Survey. Bulletin 1028–I: Geology of the Delarofand Westernmost Andreanof Islands, Aleutian Islands, Alaska. By George D. Fraser and H. Frank Barnett. Pp. v+211–248+plates 27–32. Bulletin 1045–E: Core Logs from Searles Lake, Bernardino County, California. By David V. Haines. Pp. iii+317+plates 5–10. 2 dollars. Bulletin 1052–H: Dielectric Constant and Electrical Resistivity of Natural-State Cores. By G. V. Keller and P. H. Licastro. Pp. iv+257–285. 20 cents. Bulletin 1073: Quaternary Geology of the Smoke Creek-Medicine Lake–Grenora Area, Montana and North Dakota. By Irving J. Witkind. Pp. v+80+plates 1–10. 1.75 dollars. (Washington, D.C.: Government Printing Office, 1959.) [77

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Smithsonian Miscellaneous Collections. Vol. 137 (Whole Volume): Studies in Invertebrate Morphology. (Published in Honor of Dr. Robert Evans Snodgrass on the Occasion of his Eighty-fourth Birthday, July 5, 1959.) Pp. v+416+49 plates. (Publication 4350.) (Washington, D.C.: Smithsonian Institution, 1959.) [77

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LETTERS TO THE EDITORS

COSMOLOGY

The Steady-State Universe and the Deduction of Continual Creation of Matter

DURING his recent visit to Australia, Prof. H. Bondi has re-affirmed the notion of continuous creation which he and T. Gold apparently deduced in 1948[1] from their perfect cosmological principle. This notion is also presented explicitly as a deduction in his book on "Cosmology"[2] as is evident from the following quotation from Section 12.3 (p. 143):

"The next deduction to be made from the perfect cosmological principle has formed the most controversial point of the theory. The expansion of the universe, which can be inferred either from thermodynamics or from astronomical observations, would seem to lead to a thinning out of material. By the perfect cosmological principle the average density of matter must not undergo a secular change. There is only one way in which a constant density can be compatible with a motion of expansion, and that is by the *continual creation of matter*."

On p. 144 he explains that "the creation here discussed is the formation of matter not out of radiation but out of nothing."

In the present communication it is desired to point out that the notion of continual creation from nothing is not a true *deduction* from the perfect cosmological principle, and that a scientific hypothesis can be advanced which explains the known facts within the frame of this principle.

First it should be noticed that Bondi and Gold implicitly assume that their steady-state universe must be describable in a four-dimensional space-time frame. On such an assumption the notion of creation seems to follow logically if it is also assumed that the energy density in space of all infra-red radiation may be neglected. (This last assumption does not appear to have been adequately discussed, and may well be wrong if we include the energy residing in cosmic low-frequency electro-magnetic waves.) But if we exclude this assumption, the following argument leads to another hypothesis.

Since the apparent continual escape of matter from the visible universe requires a continual supply of matter from somewhere, it is natural to suppose that this 'somewhere' exists outside our four-dimensional space-time. This hypothesis is equivalent to the hypothesis that the space-time universe U_4 is really a hyper-surface in a five-dimensional universe U_5. In thus postulating the existence of a fifth dimension to overcome a difficulty in the current framework of cosmology, we are merely following the well-established practice of postulating new entities (such as atoms, electrons, the quantum of action, etc.) to explain other phenomena which are not explicable in the current framework of science.

The notion of a universe U_5 is, however, by no means new, whether considered as a physical universe or as a convenient mathematical fiction. For example, it has been used by Kaluza[3], Klein[4], de Broglie[5], Einstein[6] and others[7] for the purpose of unifying the gravitational and electro-magnetic fields and the wave-equation of quantum theory. It is also mathematically convenient for expressing de Sitter's metric.

Thus we see that the perfect cosmological principle suggests a U_5 universe. Moreover, the hypothesis of a fifth dimension (so obtained) is fruitful since it serves not only to account for the steady-state universe of Bondi and Gold but also to unify three other great branches of physics. On the other hand, the notion of continual creation of matter does not appear to have led to any verifiable consequences of comparable importance.

There is one assertion about our U_5 which can be made immediately, namely: the laws of conservation of momentum and energy must apply in U_5 rather than in U_4. In addition there may be a law of conservation of electric charge in U_5.

The problem of formulating a metric for U_5 which is consistent with the perfect cosmological principle is under consideration. But meanwhile it seems desirable to direct attention without delay to the fact that a steady-state universe is possible without the "formation of matter . . . out of nothing".

The knowledge of this fact will undoubtedly cause relief in the minds of many persons who would otherwise be unable to accept the steady-state theory. For the old dictum *ex nihilo nihil fit* seems to be one of the few things about which philosophers, scientists and the common man agree. The contrary notion appears mainly in works which we label as "fairy-tales" or "phantasies" or in "conjuring" for entertainment.

There are many weighty reasons why a steady-state theory of the visible universe is more acceptable than its present rivals, so it is fortunate that it no longer need be associated with the primitive belief in creation. It may however be pointed out that even for an evolving (non-stationary) visible universe, our U_5 can help to prevent the 'heat-death' which current thermodynamics appears to suggest by supplying an 'outside' source of order.

In conclusion, I should like to acknowledge with thanks the benefits received from private discussions on these matters which I have had with Prof. H. Bondi, Dr. J. Moyal and Mr. D. Mustard.

V. A. BAILEY

University of Sydney.

It is not easy to see, at first sight, how Prof. Bailey's suggestion assists the reconciliation of the notion of continual creation and of ordinary ideas of conservation, as these are concerned with empirical evidence of conservation in four dimensions, and not in five. However, the value of his idea becomes clearer owing to his reference to the electromagnetic significance of five-dimensional systems. If may therefore be appropriate to mention here that Dr. R. A. Lyttleton and I. in a forthcoming paper in *Proceedings of the Royal*

Society, have investigated the connexion between a possible electric phenomenon and continual creation.

H. Bondi

King's College, London.

[1] Bondi, H., and Gold, T., *Mon. Not. Roy. Astro. Soc.*, **108**, 252 (1948).
[2] Bondi, H., "Cosmology" (Cambridge University Press, 1952).
[3] Kaluza, T., *Sitz. Preuss. Akad.*, 966 (1921).
[4] Klein, O., *Z. Phys.*, **37**, 895 (1926).
[5] De Broglie, *J. de Phys. et le Radium*, **8**, 65 (1927).
[6] Einstein, A., *Sitz. Preuss. Akad.*, 23 and 26 (1927).
[7] See the footnotes 2 and 3 to page 191 in Whittaker's "History of the Theories of Aether and Electricity, 1900–1926" (T. Nelson and Sons, Ltd., 1953), and Bergmann's "Introduction to the Theory of Relativity", Part 3 (Prentice-Hall, Inc., 1946).

RADIOPHYSICS AND GEOPHYSICS

Effect of Atomic Tests on Radio Noise

Two high-altitude atomic explosions which were set off over Johnston Island in the Pacific in August 1958 appear to have had a rather pronounced effect on the radio noise as recorded at Kekaha, Hawaii. This recording station, located on the south-west coast of the Island of Kauai, is about 700 miles north-west of Johnston Island, and is a part of a world-wide chain of noise-recording stations supervised by the U.S. National Bureau of Standards.

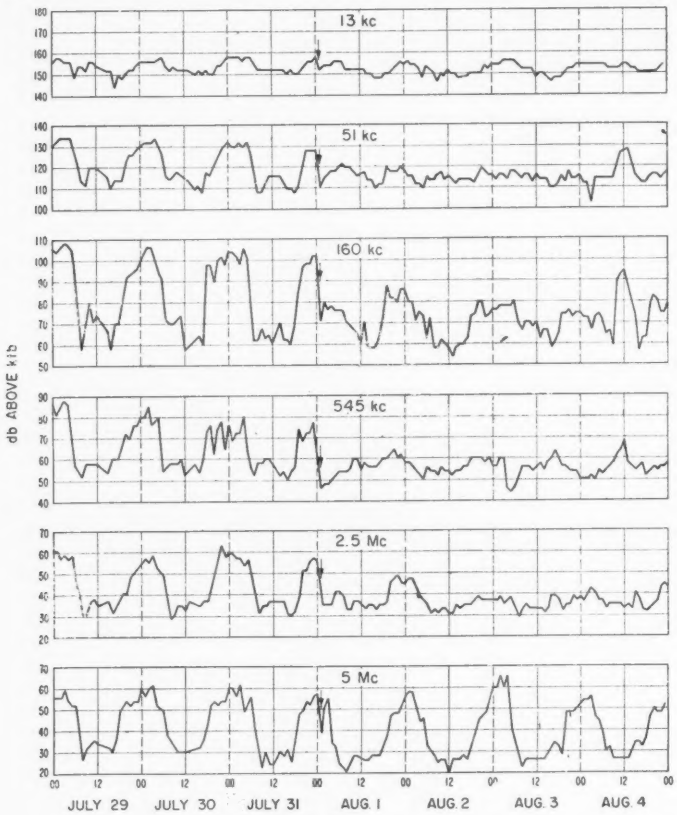

Fig. 1. Radio noise power recorded at Kekaha, Hawaii, July 29–August 4, 1958. (Time of explosion indicated by arrows)

The two bomb bursts occurred shortly after midnight on August 1 and August 12 at elevations variously reported by the Press as from 25 to 100 miles. Fig. 1 shows the atmospheric radio-noise power received for a period before and after the first explosion. The usual diurnal pattern is evident during the three days prior to the blast, with the highest noise-levels recorded at night and a rapid decrease in level between 0400 and 0800 local time. In the hour following the blast, however, the noise decreased by as much as 32 db. (at some frequencies) at a time of day when it would normally be rising or holding steady. Recovery apparently occurred in a matter of hours at 13 kc./s. and 5 Mc./s., but from 51 kc./s. to 2·5 Mc./s. a changed pattern was evident for several days with levels at night much below normal. A sudden drop in the received noise-level was also noted following the second explosion on August 12; again the noise-levels at night in the frequency range of 51 kc./s.–2·5 Mc./s. continued below normal for several days, and the usual pattern of noise was considerably disturbed until about September 1.

Because of the very low incidence of thunderstorms in Hawaii, most of the radio noise received is believed to be propagated from storms at a considerable distance. Changes in propagation conditions are reflected more clearly on the Kekaha noise records than at stations situated on large land masses, where local and short-distance storm effects tend to mask changes in propagation.

Since an omnidirectional antenna is used at the Kekaha recording station, it would seem that the

influence of the explosions may have been rather widespread, as has been suggested previously[1]. The length of time over which there was an apparent increase in the night-time absorption of noise suggests the possibility that high altitude nuclear explosions may have a rather persistent effect on radio communications at certain frequencies.

A more complete account of this noise anomaly is being prepared and will be published in the near future in the *Journal of Research of the National Bureau of Standards*, Section *D*.

C. A. Samson

National Bureau of Standards,
Boulder, Colorado.

[1] Obayashi, T., Coroniti, S. C., and Pierce, E. T., *Nature*, **183**, 1476 (1959).

The Aurora, the Radiation Belt and the Solar Wind: A Unifying Hypothesis

Recent high time resolution spectroscopic studies of the aurora[1] at College, Alaska, have revealed a rather consistent pattern in the spatial distribution of the hydrogen emission lines. It was observed that during the first phase of a typical polar auroral display the intensity peak of the hydrogen emission would shift in a continuous fashion from the northern horizon to the southern horizon in 1-3 hr. During nights of moderate auroral activity the intensity peak would remain near the southern horizon and then recede back to the north at the conclusion of the display, some time after midnight. Nights of strong auroral activity were characterized by the hydrogen emission features either disappearing below the local southern horizon, or being present in the entire portion of the magnetic meridian monitored by the spectrograph. The shift in zenith distance is interpreted as reflecting a change in the geomagnetic co-latitude of the incoming protons, as described below. The solid line in Fig. 1 represents typical data obtained in a six-day period.

In the same study it was established that certain auroral spectra can be characterized entirely by proton excitation, while others are best explained by electron excitation, the latter accounting for the greater part of the auroral luminosity. The proton associated spectra were observed during the first phase of an aurora; sometimes this occurred when the aurora was still too faint to be easily visible with the naked eye. The electron-induced aurora is associated with the break-up and post-break-up phase of a typical display. Details of the investigation are presented in another publication[1].

The latitude drift of the hydrogen emission can be explained in a semi-quantitative way by examining the effect of incoming solar particle streams (the

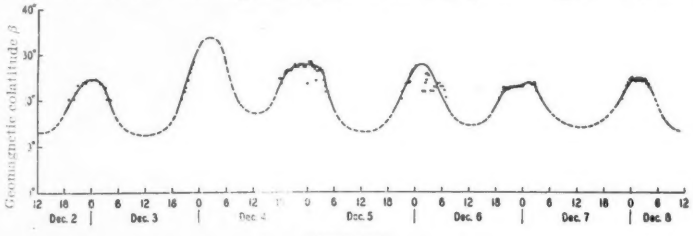

Fig. 1. Variation of the geomagnetic colatitude with time for a six-day period

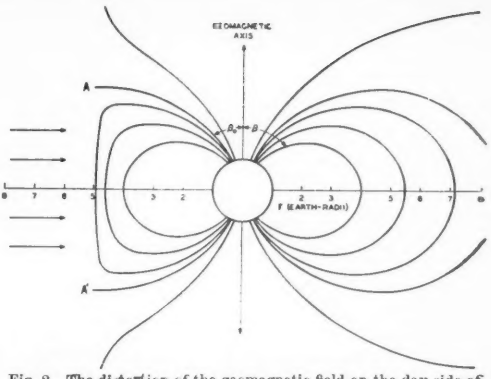

Fig. 2. The distortion of the geomagnetic field on the day-side of the earth due to an approaching solar particle stream

'solar wind' of Biermann[2] and Parker[3]) on the trapped Van Allen radiation[4]. The work of Chapman and Ferraro[5] showed that the magnetic effects of a particle stream could be represented to a first approximation by that of an image dipole situated as far behind the face of the stream-front as the Earth-dipole is in front, and that the resultant configuration of the Earth's magnetic field would be as shown in Fig. 2. The field is seen to be compressed on the day-side of the Earth, but remains almost unaffected on the night-side.

If we accept this picture, it seems reasonable to assume that the Van Allen radiation belt on the day-side of the Earth must be terminated close to the stream-front, and we shall assume further that this termination is represented approximately by the field line which meets the stream-front orthogonally (at A and A'), and meets the Earth at geomagnetic co-latitude β_0. Field lines which meet the Earth to the south of this point are 'compressed dipole' lines, while those to the north are violently disturbed by the particle stream.

The trapped particles have a slow longitudinal drift motion in the direction $\pm (H \times \nabla_1 H)$ due to the inhomogeneity of the magnetic field, and since their motion is governed by the constancy of their magnetic moment, they tend to remain in a region of constant field-strength as they drift around the Earth. Inspection of Fig. 2 shows that on the comparatively undisturbed night-side of the Earth, the trapped particles will be under the influence of field lines which intersect the Earth in a more southerly region of geomagnetic co-latitude β. Thus as the Earth rotates under this pattern, which is fixed with respect to the Sun, the region which is connected magnetically to the outer part of the Van Allen belt will move south during the evening and north again during the morning.

The extent of this latitude drift is shown in Fig. 3, which has been constructed on the assumptions that the solar particle stream consists of protons travelling towards the Earth at 1,000 km./sec., and that the stream-front is brought to rest at the point where the kinetic energy density of the stream is equal to

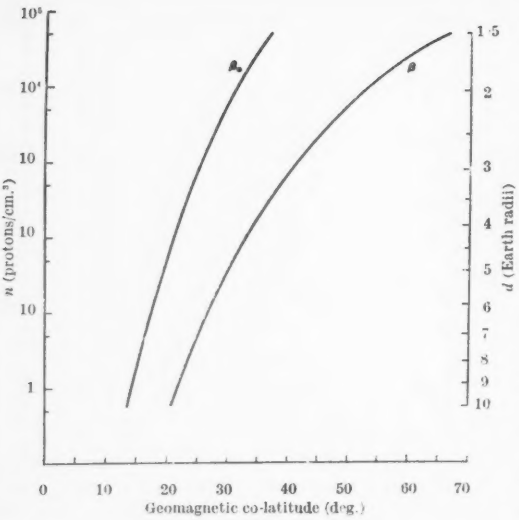

Fig. 3. Geomagnetic co-latitude of points on the Earth's surface connected magnetically to the outer edge of the Van Allen belt on the side towards the solar wind (β_o) and away from the solar wind (β). The right-hand scale shows the stationary position of the stream front and the left-hand scale gives the corresponding solar wind density, assuming the particles to be protons travelling with a velocity of 1,000 km./sec.

the increased magnetic energy density of the field. The extent of the drift can be seen to correspond roughly to the observed latitude drift of the hydrogen emission shown in Fig. 1, if moderate particle stream densities are assumed.

This correspondence leads us to suggest that the Van Allen belt contains protons which are removed by some process not yet fully understood, and which then penetrate the atmosphere and give rise to visible emissions. On this view the particles responsible for the initial stages of the aurora are not directly of solar origin, though they may be remnants of previous particle streams which have become trapped in the geomagnetic field. The Van Allen belt merely acts as a reservoir which is induced to spill over by the increase of the solar wind 'strength' on the sunward side of the Earth.

These ideas will be discussed more fully in a future publication[6] where more detailed consideration will be made of the underlying assumptions and of the processes which are operative.

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June 16.

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Colour Photography of the Aurora

Stormer[1] refers to the difficulty of photographing the aurora in colour, and states that satisfactory results have not been obtained, except for arcs and more quiet forms. However, with a colour film now available commercially, it has been found that the aurora australis can be photographed with exposure times comparable to those used in monochrome photography.

A test series of colour photographs has been taken at Scott Base, in Antarctica, during May and June of this year. Super Anscochrome daylight film (speed rating: 100 A.S.A.) has been used in an all-sky camera[2] with an $F/1{\cdot}4$ lens, and exposure times of up to 2 min. Using a standard Super Anscochrome developing kit, the speed of the film has been increased to approximately 200 A.S.A. by increasing the time of the first development 75 per cent over the recommended time. This has led to little noticeable change in the colour balance of the film.

With exposure times of 1 min., stars of the second magnitude are plainly visible on the film. A 2-min. exposure enables the Milky Way to be seen on the film. This corresponds to the visual limit of auroral observation, and is confirmed by comparisons with visual observations. An aurora just detected by a visual observer is recorded on the colour film with a 2-min. exposure. Auroræ of this intensity are below the human colour vision threshold, and thus appear colourless. (Observers frequently record these auroræ as 'faintly greenish-white'). Because of the integrating properties of the colour film, the colour 'latent' in these colourless displays is recorded on the film. Thus auroræ observed recently at Scott Base have frequently appeared white by direct observation, and red, purple, blue and white on the colour film. Spectrograms taken at the same time have shown relative spectral intensities which, it is estimated, would correspond to the colours observed with the colour film.

These observations are part of the research programme at Scott Base and are being made in conjunction with the observational programme of the Dominion Physical Laboratory Auroral Station, Invercargill, New Zealand.

The loan of the all-sky camera from the Air Force Cambridge Research Center, Bedford, Massachusetts, is gratefully acknowledged.

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Scott Base,
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Aug. 10.

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Possible Reversals of the Earth's Magnetic Field in the Jurassic Period

In a recent study of the natural remanent magnetization of the Upper Lias Sands of the West of England, seventeen samples collected from two sites were found to have reverse directions of magnetization. Samples a little higher and lower in the succession were found to be normally magnetized. Numerical details of the results and reasons for considering the rocks in question to possess a stable magnetization will be given separately.

The results are especially interesting as the sands which are exposed in various localities extending from the Dorset coast to the Cotswold Hills are all lithologically similar, and Boswell directed attention to the remarkable constancy of their mineral content and fine grade. In view of this and the fact that the sands were sampled at fourteen sites, it would be surprising if a physical or chemical mechanism were responsible for the reversed direction of natural remanent magnetization at just two sites, and it is suggested that there may have been a reversal of the Earth's magnetic field during the time the sands were being deposited.

By a careful study of ammonite species, Buckman[2,3] showed that the Sands get progressively younger towards the south although they are lithologically similar. The Upper Lias has consequently been divided into 13 sub-zones which are given by Arkell[4].

Using this sub-zonation scheme and the recent geological time-scale of Mayne *et al.*[5], it is possible to obtain an upper limit for the duration of the period of reversal. The reversely magnetized Cotswold Sands were collected from sub-zones[4] 6 and/or 7 and rocks immediately below (sub-zones 4–5) were found to be normally magnetized and the Midford Sands (sub-zones 8–9) which are exposed about thirty miles to the south are also normally magnetized. If we assume a linear division of the time-scale, we find that the Upper Lias was deposited in less than 4×10^6 years and therefore each sub-zone corresponds to approximately 3×10^5 years. A rough estimate for the period of reversal is therefore 6×10^5 years. This is a maximum estimate as the sampling was restricted to two sites and these may not, of course, have extended over two sub-zones or even one sub-zone.

It is concluded that there may have been a reversal of the Earth's magnetic field in the Lower Jurassic period which lasted for a period of less than 6×10^5 years. It is possible from Nairn's results[6] that there was another reversal a few million years later. Evidence of reversals in the Jurassic period has also been obtained from igneous rocks and baked sediments in South Africa by Graham and Hales[7] and from volcanic rocks of South America by Creer[8].

It happens that the estimate for the time of reversal compares favourably with Hosper's estimates for the reversals in the Tertiary period. In an extensive study of the Tertiary Icelandic lava flows, Hospers[9] came to the conclusion that the average length of time over which the Earth's magnetic polarity remains unchanged is $2{\cdot}5–5 \times 10^5$ years. The agreement may or may not be significant.

The results are of value in considering theories of the detailed origin of the Earth's magnetic field. Recently, both Rikitake[10] and Allen[11] have demonstrated that reversals are theoretically possible for two coupled disk dynamos and Allen has shown that oscillations of the main field with reversals at intervals of hundreds of thousands of years would be quite conceivable.

I wish to thank the Royal Dutch Shell Oil Company for a Studentship supporting the research which was carried out at the Department of Geodesy and Geophysics, University of Cambridge.

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Radiation Balance at Scott Base

Since March 1, 1957, a net exchange radiometer of the Gier and Dunkle type manufactured by Beckman and Whitley has been in continuous operation at Scott Base (77° 51′ S., 166° 48′ E.) on Ross Island. The radiometer measures the difference between the total incoming and outgoing long- and short-wave radiation through a horizontal surface 6 ft. above the ground. The site of the radiometer is such that the surface beneath the instrument is not snow at all times, because bare rock is exposed in the summer. However, the radiation-properties of the surface as a whole are probably typical of many areas in McMurdo Sound and other partially snow-free areas of the Antarctic, and the results are of particular interest for this reason.

Table 1 summarizes the first two years measurements.

For the year March 1, 1957–February 28, 1958 the net radiation gain was 17,600 cal./cm.$^{-2}$. During the following year the gain was 18,800 cal./cm.$^{-2}$. This is considerably different from substantial net yearly losses recorded over a permanent snow cover in the Antarctic[1,2,3]. Most of the positive balance at Scott Base is due to very high absorption by the rock surface in December and January when the snow cover was partially or wholly absent.

Table 1. Radiation, Cloud and Temperature at Scott Base

	March 1, 1957–February 28, 1958				March 1, 1958–February 28, 1959			
	Q cal. cm.$^{-2}$	*T* cal. cm.$^{-2}$	*C* Oktas	Temp. °C.	*Q* cal. cm.$^{-2}$	*T* cal. cm.$^{-2}$	*C* Oktas	Temp. °C.
M	− 60	4000	5·7	− 19·8	+ 290	3950	6·2	− 20·4
A	− 1720	380	4·9	− 26·6	− 2150	380	5·0	− 24·0
M	− 2510	0	3·4	− 27·1	− 2900	0	3·9	− 28·8
J	− 2040	0	4·3	− 26·0	− 2010	0	5·8	− 28·6
J	− 2350	0	3·5	− 29·3	− 3370	0	3·0	− 34·8
A	− 2340	60	4·3	− 27·7	− 2710	70	4·2	− 32·6
S	− 1990	2000	4·3	− 23·7	− 2180	2120	5·0	− 28·8
O	+ 90	9360	5·1	− 22·0	+ 680	9640	4·8	− 22·3
N	+ 2930	18040	4·4	− 9·4	+ 4100	18460	4·7	− 10·7
D	+ 11240	24230	4·8	− 4·0	+ 7850	24220	5·0	− 6·7
J	+ 12050	22550	4·2	− 3·6	+ 14500	22840	—	− 4·4
F	+ 4290	10380	6·0	− 8·0	+ 6720	—	—	− 11·5
Total ..	+ 17600	91000			+ 18800	(81700)		

Q, net flux of long- and short-wave radiation; *T*, total hemispheric short-wave radiation; *C*, mean total cloud amount, *c* = 0 – 8. Temp., mean monthly screen temperature.

During the winter months, March–October inclusive, less than ½ per cent of the area within a radius of 20 ft. of the radiometer was snow free. Towards the end of November further isolated rocks began to appear through the surface of the snow; by the end of December, 1957, 95 per cent of the ground was clear of snow; and by the end of December 1958, 40 per cent of the ground was clear. By mid-January in both 1958 and 1959 all snow had vanished, and the surface remained clear except for some very short periods following light precipitation. In February heavier snowfalls in the first week in 1958 and somewhat later in 1959 caused a return to the winter condition.

The rock is scoriaceous basaltic debris, black in colour and consisting of pieces 18-in. in diameter down to very small particles. The snow was not always perfectly clean, being at times discoloured by small particles of dust blown from the surroundings.

In November, December and January 1959 an Eppley pyranometer was mounted in an inverted position at the radiometer site, to measure the reflected short-wave radiation. Together with measurements of the hemispheric short-wave radiation, this enabled the albedo of the surface to be calculated. The mean albedos were: November 71 per cent; December 67 per cent; 1–15 January 32 per cent; 16–31 January 14 per cent. No figures are yet available for February; but it is readily seen that the differences between the observed albedos and a figure of 80–85 per cent appropriate to a clean snow surface, taken in conjunction with the hemispheric short-wave radiation, are of the right order to account for the positive balance.

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Aug. 11.

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PHYSICS

Titanium as a Gettering Material

During recent development work, it was found to be necessary to operate a cathode ray tube at a pressure materially lower than 10^{-6} mm. mercury. For this purpose, conventional barium getters were found to be inadequate, and an investigation of other materials was carried out.

The use of an ion pump was first investigated. This type of pump consists essentially of an electron-emitting tungsten source, an accelerating grid, and a negatively charged coating of titanium which could trap and absorb positively charged particles. The titanium was evaporated from an electrically heated heavy tunsgten filament. The gauge used to measure the pressure was of the cold cathode, Penning type.

When a sealed-off ion pump was attached to an ion gauge, the successful operation of the ion pump was confirmed. However, it was soon found that a comparable pumping action could be achieved merely by the use of a wall coating of titanium with no ion-forming complications.

The superior gettering power was readily demonstrated by constructing tubes with the appropriate

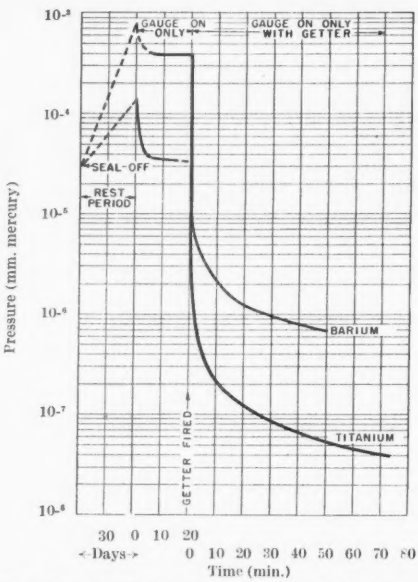

Fig. 1. Time pressure comparison of titanium and barium getters

getter material flashed on the wall, and connected to an ion gauge, the whole constructed in 'Pyrex'.

This system was outgassed at 350° C. for 1 hr. and sealed off at a pressure of 5×10^{-5} mm. mercury. When the tube containing a barium getter was fired, the pressure fell to 6×10^{-7} mm., while the tube containing titanium recorded a pressure of 2×10^{-8} mm., probably limited by the range of the gauge.

Similar systems were then constructed in 'Pyrex' which contained in addition to the getter a conventional cathode ray tube electron gun. This gun was activated on the pump before sealing off. When it was sealed off and operated at a normal temperature, a tube with the barium getter gave an ultimate pressure of 1×10^{-6} mm. mercury while a tube employing the titanium getter still registered 2×10^{-8} mm., as measured by a cold cathode gauge.

While the results of these simple experiments make it abundantly clear that the ultimate pressure obtainable with titanium is at least forty times lower than that obtained with barium, it is important to note that the gauge was in continuous operation during these measurements.

It has been well demonstrated by Alpert[1] and Bloomer and Haine[2] that the conventional hot filament ion gauge exhibits remarkable pumping properties; moreover, we have found that the cold cathode type of gauge exhibits a comparable pumping action.

Thus the use of a conventional ion gauge for the measurement of pressure is an embarrassing feature in the attempt to measure the absolute efficiency of getter materials, though there is no reason to doubt the measurements of relative efficiency which have been quoted.

For the purposes of comparison, similar experiments were performed using the hot-filament ionization gauge of the Alpert design, type *WL*5966, manufactured by Westinghouse Electric Corporation.

Two 7052 glass envelopes were fabricated, which enclosed an electron gun, a phosphor and an ion

gauge. The barium getter used was of the type 'Kemet' 61018. The titanium getter consisted of a loop of tantalum 0·030 in. diameter, around which was wound a fine titanium ribbon 0·002 in. × 0·020 in.

The two tubes were given identical treatment, being sealed on the same pump system. This system employed an oil-diffusion pump, conventional baffling, but no coolant.

The tubes were heated briefly to 325° C. and allowed to cool. The filaments of the gauge were outgassed, but the filaments of the oxide cathodes were heated only enough to drive off moisture, but insufficiently to reduce the cathode coating. Finally, the getters were outgassed. The tubes were then sealed off at a pressure of 3×10^{-5} mm. mercury and allowed to stand for 30 days, at which time measurements were begun.

The pressures were recorded and the getters fired, the ion gauges being operated continuously (Fig. 1). Again, it is seen that the final pressure is an order lower in the case of the titanium gettered tube.

The filaments of the electron gun were next heated. Marked superiority of the titanium showed except when a very large amount of gas was liberated by strongly overrunning the cathode filament. In this case, the pressures obtained were similar. On disconnecting the filament supply, a much lower pressure was again recorded in the case of the titanium getter.

Two points concerning the use of titanium have come to light during this work. To a greater extent than in the case of barium, oil vapour is apparently anathema to the absorbing powers of titanium, and oil should therefore be trapped well away from the getter.

As with other getters, it is desirable to fire the titanium as quickly as possible in order to obtain a porous layer.

It is concluded that the use of titanium as a flash getter offers the possibility of significantly lower residual pressures in most sealed-off vacuum devices.

Acknowledgment is due to the facilities and help offered by J. H. Owen Harries (in the early part of this work), and by Westinghouse Electric Corporation, where the getters have been designed for production tubes and operational results obtained.

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METALLURGY

Crack Behaviour at a Weld Structure Discontinuity

It is of both theoretical and practical interest to consider how a growing crack will behave at the structural discontinuity presented by a weld pass interface. Recently we were concerned with how a crater crack in a 5356 aluminium alloy (5 per cent magnesium type) would behave when mechanically forced to grow to the weld pass interface in a multipass weld. We have found, basically, that cracks in a multipass weld have certain significant properties which pertain to the performance and especially the structure of the weld metal.

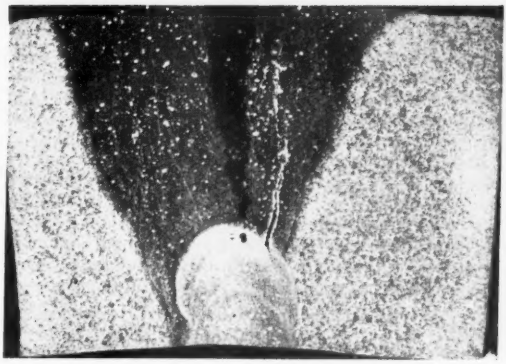

Fig. 1. Photograph of a 'Multipass Oxweld' 67 seam weld in 5356 aluminium, the crater crack originally present having been opened by plastic deformation. The dark-etching weld metal is of a rather coarse dendritic nature. Note how the two large cracks have been stopped at the weld discontinuity. There are many fine cracks present in the above sample which are not evident at this magnification (× *c.* 3·3)

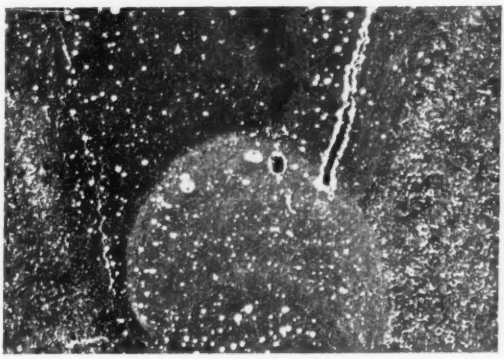

Fig. 2. The same weld specimen as in Fig. 1 (× *c.* 6). Note the left side's crack which did not encounter the other weld passes

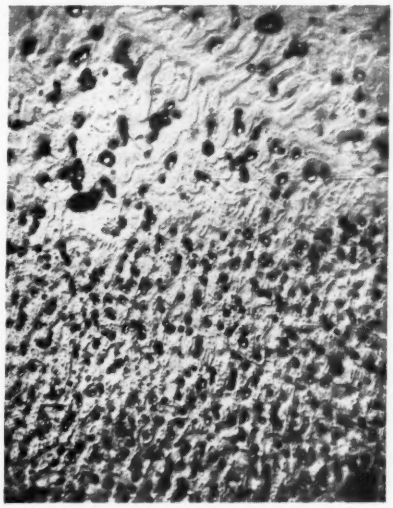

Fig. 3. The junction region between weld passes shown in Figs. 1 and 2 (× *c.* 500). Note the coarse dendritic structure of the upper (cracked) pass, the fine structure of the bottom pass

In an Oxweld 67 filler metal of a weld, one made by the Linde sigma arc process in $\frac{3}{8}$ in. thick aluminium alloy 5356, we noted metallographically that a major crack propagating in one weld pass stopped completely at the junction with another weld pass the metal of which had a finer dendritic array. These effects are shown in Figs. 1, 2 and 3.

Essentially, this means that the growing crack is reluctant to jump across the array of grain boundaries produced by the weld interface discontinuity. While this point was theoretically implied at the April 12–14 National Academy of Science—National Science Foundation Conference on "Fracture" in Swampscott, Massachusetts, this experimental finding is presented not only because it demonstrates so clearly the subject crack behaviour but also because it is a new finding of major moment to the welding designs of many engineering structures[1]. It would appear that a multipass weld in this 5356 alloy has—other things being equal—a greater crack resistance reserve in comparison with that of a single-pass weld in the same alloy. We also have, since this finding, confirmed a similar behaviour in copper-embrittled 5356 multipass welds—the cracks stop at the weld structure discontinuity when one pass of a two-pass butt weld is deliberately contaminated with copper to induce cracking therein.

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CRYSTALLOGRAPHY

Effects of Heating on X-Ray Diffraction by Carbons

A number of X-ray studies have been carried out on the diffuse bands of the diffraction patterns of carbons. The major objectives were the determination of the crystal size, the expansion of layer spacings and the atomic distribution functions of carbons of different origins and carbons subjected to heat or chemical treatment. Measurements of the thermal expansion coefficient of graphite were made by Nelson and Riley[1] and others, and more recently of graphitized carbons by Walker[2]. However, it appears that systematic studies on the effects of thermal expansion upon the more diffuse bands of amorphous carbons have not yet been made. I report here some results obtained along such lines.

A 9-cm. Debye-Scherrer camera of the type for multiple exposure film, fitted with a furnace for heating the specimen, was used. The monochromatization was achieved with Ross filters of iron and manganese which isolate the cobalt $K\alpha$ line. The diffraction patterns of carbons at 18° C. and at 800° C. through iron and manganese filters were recorded together on the same film. The patterns of the high-temperature specimens were photographed first. The resulting intensity distribution curves of the (002) band were selected and arranged in the order of the breadth and the shift of the peaks and are shown in Fig. 1, where the curves have been reduced to true intensities, corrected for polarization. All the peaks for 18° C. (full lines) and 800° C. (broken lines) are drawn at different levels. As can be seen from Fig. 1, in each case a nearly equal shift to the low angle side occurred at 800° C. Each pair of curves crosses at about $2\sin\theta/\lambda = 3{\cdot}6$ and also at the next (100) maximum to the right, where the relative intensities were the same and no peak shifts were observed as would be expected from the turbostratic structure of carbons.

The eleven samples of the curves *A* to *K* were as follows: (*A*) non-caking, low-rank Ube coal carbonized *in vacuo* at 900° C.; (*B*) low ash filter-paper carbonized as above; (*C*) cane sugar carbonized as above; (*D*) carbon-black from petroleum; (*E*) sample (*B*) heated at 1,800° C. for 30 min.; (*F*) polyvinyl chloride carbonized *in vacuo* at 900° C.; (*G*) caking bituminous Miike coal carbonized as above; (*H*) sample (*A*) heated at 1,800° C. for 30 min.; (*I*) sample (*C*) heated as above; (*J*) Omine anthracite; (*K*) sample (*F*) heated at 1,800° C. for 30 min., similar curves of other samples having rather sharp maxima have been omitted.

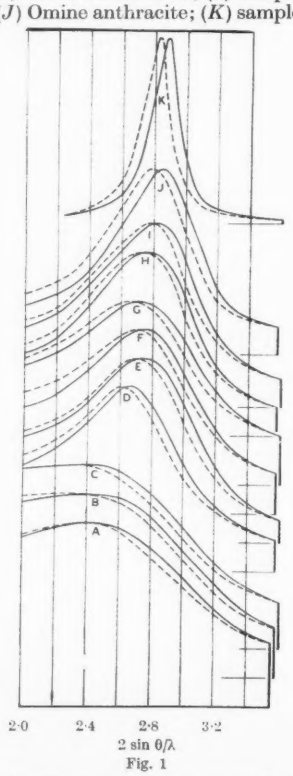

Fig. 1

The specimen rods were coated with small amounts of powdered Ceylon graphite so that the sharp (002) line of the graphite was superimposed on the diffuse band, although in Fig. 1 it has been eliminated. The comparison lines helped to determine the position of the peaks and the true temperature of the specimen, since accurate thermal expansion coefficients for the graphite are known. Under close examination a possible slight decrease of the thermal peak shift with increase of the band-width breadth was observed, but the rather intense background made this uncertain. Franklin[3] supposed that the polyvinylidene chloride char prepared at 1,000° C. consisted of paired layers of graphite and unorganized carbon, and she obtained by calculation an intensity distribution curve close to the observed (002) band. Assuming the pairs of layers

have the same thermal expansion coefficient as the bulk graphite, by using her formula a shift of the band as large as the graphite was calculated. The shift could be found on the right-hand slope of the curves in Fig. 1, however, in the present results the shifts were smaller by about 20 per cent than those of the graphite. Another result of heating appearing in Fig. 1 is the enhancement of the roentgen-amorphous scattering on the low-angle side, which was largest with the polyvinyl chloride char and least with the cane sugar char. This was confirmed by three series of experiments.

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CHEMISTRY

A Sensitive Chemical Dosimeter for Ionizing Radiation

A NUMBER of chemical systems have been employed for the measurement of the quantity of ionizing radiation. Among the most sensitive dosimeters are those employing dyes[1]. One system utilizes the destruction of a dye[2,3] and another the production of a coloured dye by transformation of the leuco form[4]. These systems are not particularly sensitive and, for a 1-mm. thick sample, would require the order of 10^3–10^4 roentgens to give a perceptible effect. During the course of our studies on the photochemistry of thiazine dyes in rigid media[5] we noticed that leuco forms of these dyes produced photochemically give a red species with ultra-violet light irradiation and a blue colour (normal form of the dye) with ionizing radiation. This latter effect is extremely sensitive, and we have pursued the matter further with the view of developing a sensitive dosimeter for ionizing radiation.

One system which is sensitive to as little as 0·5 r. of X-rays from a molybdenum target is made as follows: an aqueous solution containing 3·2 per cent polyvinyl alcohol, 0·04 per cent methylene blue, 7·0 per cent lead nitrate, 17 per cent ethylene diamine tetraacetic acid, and 8·5 per cent glycerol was dried on a glass slide to give clear blue films. The film is protected from the atmosphere by covering with a transparent pressure-sensitive tape. The film is illuminated with light from a 500-watt tungsten lamp until decolourized and allowed to stand. In order to remove trace amounts of oxygen, any restored colour is further eliminated with repeated illuminations. The film 1 mm. thick shows a blue image of the X-ray beam at dosages in the one roentgen range, the optical density of which is proportional to the dosage.

At room temperature the irradiated film exhibits a colouration which reaches full intensity about 5–10 min. after irradiation. On the other hand, an irradiated film which is stored at −10° C. will not show any colouration but will do so when warmed to room temperature. These results indicate that the oxidizing radicals formed in the plastic matrix slowly diffuse to the leuco dye molecules. The observed sensitivity is equivalent to a G value (molecules converted per 100 eV. absorbed) of the order of 10^4 in contrast to a G value of about unity for other dye systems. It is apparent that the medium is participating in some chain process.

Despite the high sensitivity of our system it still is only one hundredth that of an X-ray film (for example, Ilford, red seal, safety base). Nevertheless our system is well adapted to measure dosages by a single observation of colour, especially those in the region of greatest personal danger. Our system is obviously more convenient than liquid dosimeters and is far more sensitive.

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Some Stoicheiometric Gas Hydrates

Two communications recently appeared on the problem of the non-stoicheiometric gas hydrates and the validity of the heat content changes derived from P-T saturation-curves[3].

There is no question of the validity of the use of the Clapeyron equation:

$$\Delta H = (\mathrm{d}P/\mathrm{d}T)T\,\Delta V$$

in the determination of ΔH at points along the gas hydrate three-phase equilibrium lines, provided that it is recognized that these saturation ΔH values must be suitably corrected[2] before they are used for determination of hydrate stoicheiometry. Furthermore, this equation defines ΔH at a fixed point, say at fixed temperature T, for which the three-phase hydrate system is then invariant and for which the hydrate $M.n\ H_2O$, whether stoicheiometric or non-stoicheiometric, will have a fixed composition. The ΔH thus derived for molar transfer of hydrate-former will involve n moles of water characteristic of temperature T. The effect of any $\mathrm{d}n/\mathrm{d}T$ should appear in higher derivatives of ΔH with T.

In this connexion experimental work at present in progress (to be published) on two halogenated methanes has definitely shown that: (1) The chemical stoicheiometry derived by thermodynamic methods is equal to the ideal crystallographic value for these $M.17H_2O$ hydrates. (2) The hydrate heat capacity changes are those for $\mathrm{d}n/\mathrm{d}T = 0$.

Similarly, when a complete thermodynamic treatment, allowing for phase volume changes, gas imperfections, gas solubility and water saturation, is applied to data for methane hydrate[3] a formula $CH_4.5{\cdot}81H_2O$ is found at 0° C., whereas when only the gas compressibility correction was made the formula $CH_4.7{\cdot}18H_2O$ was obtained[3]. The importance of making all corrections to the Clapeyron ΔH cannot be overstressed, particularly when hydrate saturation pressures greater than one atmosphere are involved, for example, for argon and methane hydrates.

It appears therefore that some doubt still exists as to whether the simple gas hydrates, formed in two-component systems, do in fact present large deviations from the ideal stoicheiometry or exhibit significant changes of n along the saturation lines, except perhaps in the special case when the hydrate-former volume is near the upper limiting size for its lattice cavities, as for example ethane, methyl bromide and bromine in lattice structure I.

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Supercooling of Water Droplets

As part of a research programme designed to study the kinetics of nucleation in solutions of electrolytes, I have made some observations on the supercooling of water droplets in the form of water in oil emulsions stabilized by a number of *W/O* emulsifying agents.

The procedure adopted was to disperse the water in 'Nujol' oil containing about 5 per cent of the emulsifying agent. In this way particles which catalyse the nucleation of the water can be isolated in individual droplets, thus reducing their effect to negligible proportions. This method has been previously used in the study of the solidification of molten metals[1]. The emulsions which resulted contained a distribution of particle sizes with a sharp maximum in the region 2–4 μ. The solidification of the water was followed dilatometrically and indicated by a rapid increase in the volume of the emulsion at some well-defined temperature. The rate of cooling in the experiments was $\sim 0{\cdot}15$ deg./min.

Table 1

Emulsifier	Nucleation temperature (deg. K.)	Supercooling (deg. C.)	σ_{homo} (ergs. cm.$^{-2}$)	θ	K_s
Lanolin	257·5	15·5	16·5	84	480
Sorbitan monoleate	261·0	12·0	14·0	68	635
Sorbitan trioleate	259·5	13·5	15·1	74	590
Sorbitan sesquioleate	260·0	13·0	14·7	72	585
Soymul A.B.	259·5	13·5	15·1	74	590

In these experiments much smaller degrees of supercooling were observed than previously reported by other workers[2]. This I attribute to the formation of ice crystals on the inside surface of the droplets and catalysed by this surface. Since it is reasonable to suppose that molecules of emulsifying agent adsorbed on the droplet surface should not show any long-range order or 'crystallinity', this catalytic effect cannot be attributed to epitaxial growth on the droplet surface as is the case with the seeding of ice crystals by silver iodide. There is not sufficient evidence to say why the ice forms at the surface (heterogeneous nucleation) instead of in the bulk of the droplet (homogeneous nucleation), but the electrical charges which reside at the surface of the droplet and are presumably responsible to some extent for the stability of the emulsion, may also play some part in the catalytic activity of the surface.

From the nucleation theories of Volmer and by assuming that the nucleus forms as a spherical cap on the inside of the droplet, I have estimated values for the angle of contact θ, between the critical ice nucleus and the surface of the droplet and also the number of molecules K_s, in this critical nucleus. (Table 1). Values for the interfacial energies σ_{homo}, are interpolated from the results of Jacobi[3].

My thanks are due to Dr. P. Sherman of the Gestetner Co., London, for information concerning the emulsifying agents.

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BIOCHEMISTRY

Extraction of the Total Protein from Wheaten Flour in the Form of Soluble Derivatives

Swan[1] has recently developed a method for solubilizing keratins which depends on the fission of cystine disulphide bonds by reaction with cupric and sulphite ions, with the formation of S-sulpho cysteine residues. The protein when modified in this way becomes water-soluble, with amino-acid residues other than cysteine and cystine unchanged. Swan's method has been applied by Pechère, Dixon, Maybury and Neurath[2] to trypsinogen and chymotrypsinogen, and in these cases also the resulting S-sulpho derivatives were water-soluble.

We have found that when Swan's method is applied to white flour (approximately 70 per cent extraction) the protein is readily dissolved. Most of the starch remains as an insoluble residue which may be separated by centrifugation from the clear solution containing the protein derivatives; less than 3 per cent of the carbohydrate is solubilized with the protein, and this includes pentosan material. Table 1 giving the nitrogen content of the insoluble residue, shows, for flours derived from different wheats, that the extraction of protein is virtually complete.

Table 1

Wheat	Manitoba	Svenno	Bersee	Hybrid 46
Nitrogen in flour (per cent)	2·31	2·47	2·11	1·68
Nitrogen in residue (per cent)	0·03	0·03	0·06	0·01

10 gm. defatted flour extracted at room temperature for 1–2 hr. with 125 ml. of reagent essentially similar to that described by Swan. The mixture centrifuged and the insoluble residue washed and centrifuged successively with 0·1 *M* ammonia, water, 1 per cent acetic acid, water

The solution containing the protein may be freed from copper after removal of excess reagents by dialysis against 0·1 *M* ammonia by dialysis against ethylenediaminetetraacetate in 0·1 *M* ammonia or against 0·1 *M* hydrochloric acid. The solubility of the protein derivatives is extremely sensitive to *p*H. The solutions are clear at *p*H 7·5–8·0 but, in the presence of McIlwaine's buffer, precipitation occurs at *p*H 7·0 and increases to a maximum at about *p*H 4·0.

The proteins in gluten, freshly washed out from flour, are also solubilized by the Swan process—when the material is left in contact with the reagent overnight at room temperature. Some of the carbohydrate contained in the gluten complex is also dissolved.

Work is proceeding on the separation of the soluble carbohydrate from the soluble protein derivatives and on a comparison of these derivatives from wheats of different types.

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Interaction of Anti-Staling Agents with Starch

Following an observation that sucrose stearate, a compound claimed to have anti-staling activity, precipitated starch from solution (to be published), the study was extended to other substances known to have anti-staling properties.

As most known anti-staling agents have surface-active properties, two surfactants were included in the programme—a sulphonated hydrocarbon (anionic) and cetyl trimethyl ammonium iodide (cationic). For purposes of comparison, *n*-butanol and thymol (amylose precipitants) were also included.

The following compounds, claimed to have anti-staling activity, were tested: sucrose monostearate, sucrose distearate, polyoxyethylene monostearate, glyceryl monostearate (commerical), glyceryl monostearate (pure, Myverol 18-06) and stearoyl tartrate.

Solutions of the test agents were added to solutions of wheat starch to give final concentrations: starch 0·5 per cent, sodium chloride 0·05 per cent, test agent 0·005–0·075 per cent (except in the case of stearoyl tartrate where the maximum concentration was 0·03 per cent, due to its low solubility). The amount of precipitate was determined turbindimetrically.

Butanol, thymol and the two ionic surfactants had virtually no precipitating effect in this concentration range. Among the anti-staling agents only stearoyl tartrate showed little precipitating power. The most effective precipitants were sucrose monostearate, glyceryl monostearate (pure) and polyoxyethylene monostearate. Glyceryl monostearate (commercial) was slightly less effective and sucrose distearate much less effective.

These results show that five out of six substances with anti-staling activity give a precipitate with starch. Whether or not this reaction is a pre-requisite for all anti-staling agents is not certain, but in any event this reaction must change the characteristics of flour products.

Ofelt *et al.*[1] reported that glyceryl monostearate decreased the crumb firmness of bread (an anti-staling characteristic) and that glyceryl distearate had no such effect, nor did it act synergistically with the monostearate. Our results show that glyceryl monostearate (pure) is a more effective precipitant for starch than the commercial material, but only slightly so. However the commercial glyceryl monostearate employed contained about 33 per cent monostearate with the remainder largely distearate. If there were a strict parallel between the baking and precipitation tests, it would be expected that there would be a greater difference between the two samples of glyceryl monostearate in the precipitation tests. Ofelt *et al.*[2] also found that the crumb softening effect decreased in the order polyoxyethylene monostearate, glyceryl monostearate, sucrose monostearate but the precipitation tests showed little difference between the three compounds. In addition, Axford and his colleagues[3] have found no direct correlation between the amount of precipitate which we have observed with starch and the effectiveness of an anti-staling agent in bread. Thus one is led to the conclusion that complex formation between known anti-staling agents and starch must occur in flour products and that it may well explain the action of these agents as bread improvers; if this is so, then the effectiveness of such an agent in bread must be determined not only by the amount of complex formed, but also by the properties of that complex, such as its permeability to moisture.

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A New Inhibitor of Serotonin Metabolism

It has been postulated that a change in amine concentrations in the brain is causally related to the activity of a drug in the central nervous system. In 1940, Mann and Quastel[1] suggested that the central stimulant activity of 'Benzedrine' was related to its ability to inhibit the oxidation of tyramine by amine oxidase. Follows and Bernheim[2] observed an excellent correlation between the increased motor activity in the rat and the inhibition of amine oxidase by a series of aryl-2-aminopropane derivatives. Recently, Tedeschi *et al.*[3] observed that *SKF* No. 385, 2-phenyl*cyclo*propylamine, in the rabbit, demonstrated an activity suggestive of *in vivo* monoamine oxidase inhibition. Since this compound was not a hydrazine, it was decided to study its effect on amine oxidase activity.

In vitro amine oxidase activity was determined[4,5] by measuring the rate of disappearance of serotonin incubated with rat brain homogenates. Adult male rats were killed by exsanguination, the brains were rapidly removed, weighed and homogenized in 2 volumes of distilled water. 1 ml. of brain homogenate was added to 300 μgm. of serotonin in phosphate buffer and the mixture incubated for 60 min. at 37° C. Optimal substrate concentration was determined to be 300 μgm., and serotonin disappearance was found to be linear between 15 and 60 min. A 15-min. preincubation of the drug with the rat brain homogenate, prior to the addition of substrate, was utilized to obtain maximal inhibition. Serotonin

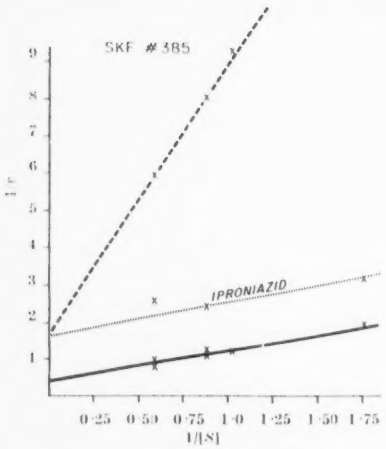

Fig. 1. Lineweaver Burk (ref. 7) plot of the effect of *SKF* No. 385 and 'Iproniazid' on the rate of disappearance of serotonin incubated with rat brain homogenate

was isolated and determined colorimetrically by the method of Udenfriend *et al.*[6].

The effectiveness of *SKF* No. 385, 2-phenyl*cyclo*propylamine, 'Dexedrine', 2-phenyl *iso*propylamine, and 'Iproniazid', 1-*iso*nicotinyl-2-*iso*propylhydrazine, on the disappearance of serotonin was determined over a wide range of drug concentration.

A sigmoid-shaped curve was obtained by plotting per cent inhibition against drug concentration, serotonin disappearance being inhibited 50 per cent by *SKF* No. 385 at $2{\cdot}8 \times 10^{-6}$ *M*, by 'Dexedrine' at 7×10^{-5} *M* and by 'Iproniazid' at 7×10^{-4} *M*. Substrate concentration was then varied and a Lineweaver and Burk[7] plot of the results suggested that *SKF* No. 385 was a non-competitive inhibitor (Fig. 1).

To determine their *in vivo* inhibitory activity these compounds were administered to the rat and the serotonin content of whole brain was determined spectrofluorometrically by the method of Bogdanski *et al.*[8].

'Iproniazid', administered intraperitoneally at doses of 25–100 mgm./kgm., increased the rat brain serotonin content 30 and 60 per cent, respectively, above control animals. However, administered orally for comparison with *SKF* No. 385-*A*, 'Iproniazid' was found to have little effect on brain serotonin content (Table 1). *SKF* No. 385-*A* was active orally at doses of 2·5 mgm./kgm., 65 per cent increase, but the maximal response obtained at 10 mgm./kgm. (Table 1) was unchanged at doses up to 60 mgm./kgm. 'Dexedrine', *in vivo*, had no effect on the level of serotonin in whole brain. Therefore, it would

Table 1. Effect on Rat Brain Serotonin of 'Iproniazid' and *SKF* No. 365-*A*, Administered Orally

Time (min.)	Serotonin, μgm./gm. of brain	
	'Iproniazid' 400 mgm./kgm.	*SKF* No. 385-*A* 10 mgm./kgm.
0	0·53 (6)*	0·48 (10)
30	0·51 (2)	0·70 (4)
60	—	0·74 (3)
120	0·56 (2)	0·80 (4)
180	0·66 (6)	1·08 (10)
240	0·86 (2)	0·86 (4)
300	0·65 (2)	

* The figures in brackets are the number of animals killed to obtain the average serotonin content recorded.

appear that, in agreement with Vogt[9], the excitatory reactions following the administration of 'Dexedrine' are not due to an accumulation of serotonin in the brain.

The results obtained with 'Iproniazid' are in agreement with Zeller and Barsky[10], Schayer[11] and Sjoerdsma *et al.*[4], who have reported on the *in vitro* and *in vivo* inhibition of monoamine oxidase by 'Iproniazid'. However, the far greater inhibitory activity of *SKF* No. 385, a non-hydrazine compound, both *in vitro* and *in vivo*, opens a whole new area of search for pharmacologically active stimulant drugs.

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Infra-Red Spectra of Carbohydrate Sulphate Esters

In recent years considerable interest has been expressed in the use of infra-red spectroscopy in studies on the location of the ester sulphate group in the isomeric chondroitin sulphuric acids, *A*, *B* and *C*. Although Orr's[1] original assignment of bands in the 700–1,000 cm.$^{-1}$ region of spectra of sulphated mucopolysaccharides has been criticized[2], his views have recently received further support from the work of Mathews[3], and Meyer and co-authors[4].

Accumulated evidence from studies of the infra-red spectra of chondroitin sulphate isomers indicates that apart from a band of strong intensity at 1,240 cm.$^{-1}$ which is associated with the S–O stretching vibration, displacement of bands in the 800–850 cm.$^{-1}$ region, attributed to vibrational modes involving stretching in the C–O–S system can be associated with the spatial distribution of sulphate groups on the hexosamine moieties. Observations[1–4] of the presence of the characteristic band at 820 cm.$^{-1}$ in chondroitin sulphate *C*, and at 850 cm.$^{-1}$ in chondroitin sulphates *A* and *B*, and the disappearance of these bands following chemical desulphation[5], have been repeated in the Cardiff laboratories. Moreover, persistence of the 850 cm.$^{-1}$ band in the spectrum of N-acetylchondrosin sulphate isolated from chondroitin sulphate *A* after enzymic hydrolysis[6] has also been noted.

The development of methods for the definitive synthesis of hexose and hexosamine monosulphate esters[7] has now provided another approach to this problem. Sulphation of glucose, galactose, and N-acetylglucosamine to yield the corresponding monosaccharide-6-O-sulphate esters is accompanied by the appearance in the infra-red of new bands at 1,240 cm.$^{-1}$ and 820 cm.$^{-1}$. Preparations of N-acetylgalactosamine monosulphate[7], the structure of which

has still not been established with certainty, also exhibit these characteristic absorption frequencies. On the basis of these observations the association of the 820 cm.$^{-1}$ band with the 6-O-sulphate position in the monosulphate esters of glucose, galactose and N-acetylglucosamine may be postulated. By analogy, the location of the sulphate group on position 6 of N-acetylgalactosamine monosulphate, for which some preliminary evidence has already been obtained[7], may also be proposed. Evidence supporting these views may be derived from the fact that cerebron sulphate, in which the sulphate group has been assigned to position 6 of the galactose moiety[8], also exhibits the 820 cm.$^{-1}$ band. Consequently, the proposed correlation between the 820 cm.$^{-1}$ band of chondroitin sulphate *C*, and substitution of the 6 (equatorial) position of galactosamine residues in this polymer is well supported.

The establishment of the sulphate group on the 4 (axial) position of galactosamine in chondroitin sulphate *B* by methylation studies[9], supports the assignment of the 850 cm.$^{-1}$ band to sulphation of position 4 of the hexosamine moiety of this compound, and, by analogy, of chondroitin sulphate *A*. Additional evidence in favour of these postulates is obtained from the appearance of the 850 cm.$^{-1}$ band in spectra of *Chondrus ocellatus* mucilage polysaccharide (gift from Prof. T. Mori), and carrageenin (gift from Dr. F. A. Rose), in which the sulphate group has been established as being on position 4 of galactose by methylation studies[10].

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Interference by Azide with Diazotization Procedures used in Biological Assay Systems

When sodium azide (5×10^{-3} *M*) was added as an inhibitor of nitro-reductase activity of a *Nocardia sp.* using *p*-dinitrobenzene as substrate we were unable to detect the formation of *p*-nitroaniline by means of a diazotization assay[1] although the appearance of a yellow colour indicated its formation. However, after extracting the reaction mixture with ether it was possible to show electrophoretically the presence of *p*-nitroaniline in the ether extract and that sodium azide at the above concentration has no inhibitory effect on the nitro-reductase system.

We later studied the effect of sodium azide on the *p*-nitroaniline assay system using known concentrations of arylamine compounds. To a series of 15 ml. centrifuge tubes containing 10 μgm. of either *p*-aminobenzoic acid or *p*-nitroaniline, plus various concentrations of sodium azide, in a total volume of 2 ml. of distilled water, were added at room temperature 0·5 ml. *N*-hydrochloric acid and 0·25 ml. aqueous sodium nitrite (0·1 per cent w/v). After 5 min. 0·25 ml. ammonium sulphamate (0·5 per cent w/v.) was added and thoroughly mixed. Three minutes later 0·25 ml. of *N*-(1-naphthyl)-ethylenediamine hydrochloride (0·1 per cent w/v.) was added. After 30 min. at room temperature the optical density of the solution was estimated at 540 mμ using the Beckman model *DU* spectrophotometer. The results (Table 1) demonstrate a marked inhibitory effect of sodium azide on the diazotization reaction.

Table 1. Effect of Sodium Azide on Diazotization Reactions

Concentration of sodium azide added (*M*)	Colour formation with: *p*-Aminobenzoic acid		*p*-Nitroaniline	
	Optical density at 540 mμ	Inhibition (per cent)	Optical density at 540 mμ	Inhibition (per cent)
None	1·030	—	1·200	—
1×10^{-4}	1·030	—	1·176	2
5×10^{-4}	0·824	20	0·804	33
1×10^{-3}	0·402	61	0·372	69
5×10^{-3}	0·082	92	0·010	100
1×10^{-2}	0·010	100	0·010	100

Sodium azide has been reported by many workers to inhibit the activities of several enzyme systems (nitrate and nitrite reductases, nitroethane oxidase, organic nitrate reductase, and nitroaryl reductases, among others) in which the diazotization reaction was used to determine the extent of the reaction. In the light of the findings reported here it might be of interest to reinvestigate the effect of sodium azide on these enzyme systems.

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Immunochemical Studies of Polypeptidyl Proteins and Synthetic Polypeptides

The polymerization of N-carboxyamino-acid anhydrides[1] has made available synthetic polypeptides of high molecular weights which consist of a single polypeptide chain containing one type of amino-acid residue; copolymers of two or more different amino-acids; or multichain polypeptides. The molecular weights and some chemical and physical properties are similar to those of proteins.

It is also possible to link chemically synthetic polypeptides to protein molecules by initiating polymerization of N-carboxyamino-acid anhydrides with proteins[2], yielding modified or polypeptidyl proteins which are chemically very similar to the native protein. Because the antigenic character of proteins may be associated with their polypeptide structure, we have studied the immunological properties of polypeptidyl proteins and synthetic polypeptides[3,4].

Preparations of bovine serum albumin modified by the addition of peptides of glutamic acid, lysine, leucine, or phenylalanine[2] were strongly antigenic in

rabbits. Precipitin reactions were obtained between antisera to each polypeptidyl bovine albumin and a similarly modified rabbit serum albumin or unmodified bovine albumin, indicating the presence of antibodies specific for each of the added peptides and for the carrier protein. The antisera to the polyleucyl and polyphenylalanyl bovine albumins were able to precipitate the homologous antigen after absorption with a similarly modified rabbit serum albumin and the unmodified bovine serum albumin, suggesting that a third type of antibody had been formed which required the added peptide and a part of the carrier protein.

Similarly modified rabbit albumins[2] were also antigenic in rabbits. Their antisera gave precipitin reactions with the correspondingly modified bovine albumins. Absorption experiments showed some antibodies were formed to the polyleucyl and polyphenylalanyl rabbit albumins which were specific for the modification and others which required the added polypeptide and a part of the carrier protein.

Antisera to the polypeptidyl proteins cross-reacted with several purified protein preparations with which antiserum to the unmodified bovine albumin did not. The modification of the bovine albumin with the various polypeptides reduced the amount of antibody precipitated by the polypeptidyl albumin from an antiserum against unmodified albumin.

Twenty-five different synthetic polypeptide preparations, not linked to a carrier protein, were tested for antigenicity in rabbits. Linear polypeptides studied were: a series of acidic polyglutamic acids of molecular weights of about 1,200–80,000; two basic polylysine preparations; polyleucine and polyphenylalanine—neutral polypeptides insoluble in water; polyproline—neutral and water-soluble; and several copolypeptides of two different amino-acids. A complex multichain polypeptide of glutamyl, leucyl, glycyl, and lysyl residues was also studied.

Only one of the polyglutamic acids and the multichain polypeptide vere sufficiently antigenic to cause the formation of antibody titres high enough to give definite zones of precipitation in agar diffusion tests and to measure by quantiative precipitin methods. The antibodies formed did not precipitate with the homologous synthetic polypeptide, but cross-reacted with related polypeptidyl albumins and certain purified protein preparations. Antisera against a few other synthetic polypeptides gave weak, questionable precipitin tests. The antisera to the polyglutamic acid and multi-chain polypeptide produced weak anaphylactic reactions in guinea pigs challenged with the homologous or a simlar synthetic polypeptide and moderate to fatal anaphylactic shock in guinea pigs challenged with polyglutamyl bovine albumin or unmodified bovine albumin.

The synthetic polypeptides did not inhibit precipitin or anaphylactic reactions between their antisera and cross-reacting proteins or between antisera to similarly modified proteins and their homologous antigens. The reaction between modified rabbit proteins and antibodies to modified proteins were more easily inhibited by high salt concentrations than precipitins of unmodified proteins. A few polyglutamic acid preparations, which gave no precipitate with their antisera in physiological saline, gave specific precipitates when the ionic strength was lowered to 0·05, suggesting that ions react with the highly polar polypeptide to prevent precipitin formation. The high charge of the soluble synthetic polypeptides may hinder the formation of a stable combination between the polar antigen and antibody as compared to proteins and so block precipitation or inhibition reactions and reduces antigenicity.

We conclude that a few of the synthetic polypeptides studied incited antibody formation in rabbits. The polypeptides coupled to bovine or rabbit albumin[4] were all antigenic. The precipitin reaction of highly polar, synthetic, soluble polypeptides and their antisera was weak and more sensitive to ionic strength than reactions of protein antigens. Antisera to some synthetic polypeptides cross-reacted with certain purified proteins. The structural requirements for the antigenicity of synthetic polypeptides, like that of proteins, is not yet understood. Continued study of the immunochemical properties of the model synthetic polypeptides and polypeptidyl proteins, may contribute to our understanding of the structural basis for antigenicity and of antibody-protein reactions.

Further details will be published elsewhere.

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Occurrence and Quantitative Determination of 2-Dimethylaminoethanol in Animal Tissue Extracts

Recently the function of 2-dimethylaminoethanol (Deanol) in the biosynthesis of choline and its role as a possible precursor of cerebral acetylcholine[1] has intensified interest in this substance. Levine and Chargaff[2] could not find it in phospholipides. Artom and Crowder[3] claimed the occasional occurrence of traces of it in rat liver. Recently Wolf and Nyc[4] reported that they were able to isolate it from a mutant strain (47904) of *Neurospora crassa*, which accumulates this substance. In a preliminary paper, Venkataraman and Greenberg[5] showed on the basis of chromatographic evidence, that incubation of a rat liver extract with aminoethanol and formaldehyde yielded methylated intermediates of choline. To clarify the question of the natural occurrence of 2-dimethylaminoethanol in animal tissue a method was developed for the isolation, characterization and quantitative determination of small amounts of this substance in the presence of other amines.

For the separation of bound and unbound amines the tissue was homogenized in 80 per cent ethanol, adjusted to a *p*H of 2–3 with concentrated hydrochloric acid and centrifuged. This extraction was repeated 3–4 times. The ethanolic extract contained the unbound amines, whereas the bound amines remained in the precipitate. In order to obtain the volatile components of unbound amines, the supernate was concentrated *in vacuo* (water bath tempera-

ture 40–50° C.), saturated with barium hydroxide and subjected to a fractional steam distillation *in vacuo* (15–25 mm. mercury) under nitrogen. Four different fractions (*F* 1–4) were collected in 1 *N*-hydrochloric acid at increasing water-bath temperatures. (*F*1: 14–19° C. 90 min., *F*2: 19–36° C. 10–15 min., *F*3: 36–55° C. 60–75 min., *F*4: 55–60° C. 60–75 min.). The excess hydrochloric acid was removed under reduced pressure. To liberate the bound amines, the residue from the steam distillation and the ethanol insoluble precipitate were refluxed for 6 hr. in a saturated barium hydroxide solution. This hydrolysate was subjected to an extraction with 80 per cent ethanol at *p*H 2, or to a preliminary steam distillation *in vacuo* under nitrogen and the volatile amines collected in 1 *N* hydrochloric acid. The crude amine mixture was then fractionated by the procedure described for the unbound amines (fractions *FH* 1–4). The fractional steam distillation served to separate amines like ammonia and methylamine, which occur in relatively large quantities, from the other tissue amines. The main amount of 2-dimethylaminoethanol appeared in fractions *F* 3 and *FH* 3 whereas most of the ammonia and methylamine came off in *F* 1 and *FH* 1 and 2.

The separation of the small amounts of 2-dimethylaminoethanol found in tissues from the amines and aminoalcohols, which are usually present in much larger quantities, is rather difficult. Paper-electrophoresis and paper-chromatography are not entirely satisfactory since these amines have similar migration properties in these systems. These methods are useful for the further characterization of the amines after recovery from the separation by gas-phase-chromatography. The electrophoresis was carried out on Whatman paper No. 1 (57 × 15 cm.; buffer content 130–150 per cent) in 1/10 *M* citric acid buffer, *p*H 3·8, at 1000 volts (12 m.amp.) for 90 min. The ascending chromatogram was developed overnight on Whatman paper No. 1 (18 × 38) impregnated with the citric acid buffer. The solvent mixture: butanol: ethanol: water: acidic acid = 8:4:3:1 was used. The detection of the amines on paper is limited by the sensitivity of the dye-reaction. Under the best experimental conditions 15–20 μgm. of 2-dimethylaminoethanol could be detected with potassium-bismuth-iodide. The optimal results were obtained by gas-phase chromatography. For the separation of the individual components of the amine mixtures by this technique, the amine hydrochlorides were converted to the free amine form by treatment with 1 per cent methanolic sodium hydroxide and this solution was injected into the following gas-phase-chromatography system: the support, 'Chromosorb' (Johns Manville, mesh size 30–60) pretreated with 5 per cent methanolic sodium hydroxide was mixed with the stationary phase, 'Carbowax 20 *M*', 24–26 weight per cent dissolved in methanol acetone (3:1). This mixture was stirred until dry and packed in a 5-ft. column, which was put in a Wilkens aerograph instrument. Helium, 96 ml./min., was used as carrier gas, and the temperature was kept at about 125° C.

Fig. 1 shows the clear resolution of a test mixture containing 1-dimethylamino-2-propanol, 2-dimethylamionoethanol, 2-diethylaminoethanol, 2-methylaminoethanol, 2-aminoethanol and phenylethylamine.

The quantity of 2-dimethylaminoethanol was determined from the peak area on the gas-chromatogram (peak height × half width) as suggested by Cremer[6]. From known amounts of pure 2-dimethylaminoethanol solutions a standard curve was drawn and used in the quantitative estimation of this substance in natural sources. The error of the quantitative estimation ranged from 1–2 per cent (with quantities above 20 μgm.) to 10 per cent (with quantities less than 20 μg). The smallest amount of 2-dimethylaminoethanol detectable (with the thermoconductivity cell, filament current 250 m.amp. and a 1 mV. Bristol recorder full sensitivity) was 0·1–0·5 μgm.

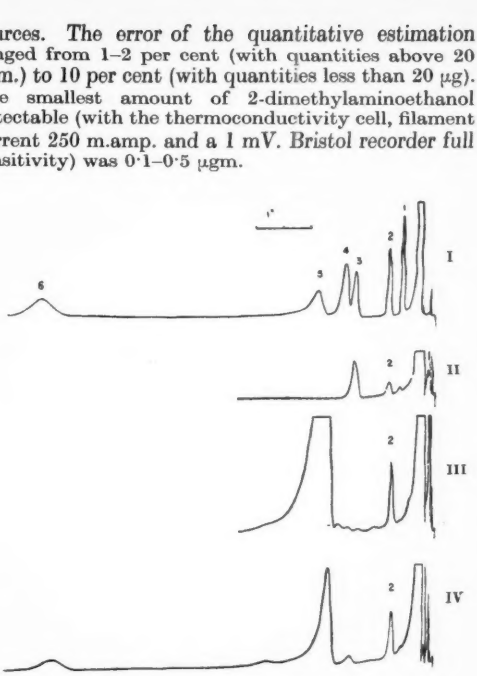

Fig. 1. Gas-chromatogram of test mixture and tissue extracts. I, test mixture; II, *FH*4 human brain; III, *F*3 pig brain; IV, *F*4 salmon roe. Peak 1, 1-dimethylamino-2-propanol; peak 2, 2-dimethylaminoethanol; peak 3, 2-diethylaminoethanol; peak 4, 2-methylaminoethanol; peak 5, 2-aminoethanol; peak 6, phenylethylamine.

The procedure for the quantitative isolation of 2-dimethyl aminoethanol was checked for accuracy as follows: to 13·6 gm. salmon roe 1 mgm. of 1,2-C^{14}-labelled 2-dimethylaminoethanol was added. After completion of the isolation for bound and unbound 2-dimethylaminoethanol, an aliquot of the amine extract equivalent to 1 μgm. of added 2-dimethylaminoethanol was injected into the gas-chromatograph; the collected peak contained 99 per cent of the expected radioactivity.

Tissue extracts from about 1 kgm. of human brain, pig brain and salmon roe were prepared, and the amounts of 2-dimethylaminoethanol determined in the manner described (see peak 2 in Fig. 1). In the case of salmon roe, which is relatively rich in 2-dimethylminoethanol, the peak corresponding to this substance was collected at the outlet of the gas-chromatograph and further characterized by paper-electrophoresis (migration value 0·64 where glycine has a migration value of 0 and methylamine a migration value of 1·0) and paper-chromatography (R_F value 0·27). It was shown that the peak has the same migration properties and the same dye-reaction in both systems as pure 2-dimethylaminoethanol.

The quantities of 2-dimethylaminoethanol found in these tissues were as follows: in salmon roe 260 μgm./kgm. unbound and 1662 μgm./kgm. bound, in human brain 5·1 μgm./kgm. unbound and 76·4 μgm./kgm. bound, and in pig brain 173 μgm./kgm. unbound and 73·5 μgm./kgm bound.

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Tropolone Biosynthesis: the Enzymatic Decarboxylation of Stipitatonic and Puberulonic Acids

Isotope tracer studies have established an important role for acetate and formate in the biosynthesis of stipitatic acid (6-hydroxytropolone-4-carboxylic acid) by *Penicillium stipitatum* and it is probable[1] that the C_7 tropolone ring is not formed by ring expansion from known C_6 structures as proposed by Seshadri[2]. Seshadri also suggested 6-hydroxytropolone-3,4-dicarboxylic acid as the immediate precursor of stipitatic acid. This possibility seemed likely since other *Penicillium* species yielded the compounds puberulic and puberulonic acids[3] which are now known to be 6,7-dihydroxytropolone-4-carboxylic acid and the anhydride of 6,7-dihydroxytropolone-3,4-dicarboxylic acid, respectively[4]. Recently Segal[5] isolated from *P. stipitatum* cultures an anhydride, stipitatonic acid, originally believed to be the 6-hydroxytropolone-3,4-dicarboxylic acid proposed by Seshadri, but now established as the 4,5 isomer[6]. Although puberulonic acid is usually written as indicated above, it seems reasonable to suppose that any adjacent pair of the four oxygen functions may form the tropolone function and it may equally be regarded as 3,4-dihydroxytropolone-5,6-dicarboxylic acid, or analogous to stipitatonic acid, as 3,7-dihydroxytropolone-4,5-dicarboxylic acid.

In the light of these structural considerations it seemed possible that the final stage of the Seshadri hypothesis might be correct in principle, but that the precursors of the tropolone monocarboxylic acids were the 4,5- rather than the 3,4-dicarboxylic acids. We have therefore investigated the enzymatic decarboxylation of both stipitatonic and puberulonic acids.

The enzyme preparations were obtained from *P. stipitatum* NRRL 2104 cultures grown in 1-litre Erlenmeyer flasks on 200 ml. of Czapek-Dox medium supplemented with 0·1 per cent yeast extract and 0·3 per cent corn steep liquor. On the eighth or ninth day after inoculation the mycelial pad was ground with glass beads and 0·1 *M* phosphate buffer, *p*H 5·8, (about 7 ml. per culture) essentially as described for *cis*-aconitic acid decarboxylase by Bentley and Thiessen[7]. The paste obtained by this treatment was centrifuged with an additional portion of the buffer at 1860 *g* for 25 min. to remove the powdered glass and cell debris. The cloudy supernatant was further centrifuged at 24,500 *g* for 30 min. and the resultant supernatant filtered through a rapid paper. The preparation was used as such or could be dialysed for a short time against cold, distilled water without loss of activity. A typical preparation was a pale yellow opalescent solution at about *p*H 6 and contained 5·0–5·5 mgm./ml. of protein.

The decarboxylase activity was measured manometrically by observing the evolution of carbon dioxide at 37° with stipitatonic acid as substrate. The stipitatonic acid solution (8–10 μmoles/0·4 ml.), prepared by dissolving the anhydride in 0·1 *M* phosphate buffer, *p*H 7·5, with warming, was added from the side arm after equilibration. The preparations showed a small and variable oxygen uptake in the absence of substrate and all experiments were corrected for this. The decarboxylase was active over a broad *p*H range with a maximum at about *p*H 6·6. However, assays were usually run at a slightly lower flask *p*H (about 6·0–6·2) so that evolution of carbon dioxide could be followed manometrically with appropriate corrections for retention of carbon dioxide. Under these conditions a linear production of carbon dioxide was obtained for 90 min., corresponding to about 1·4 μl. carbon dioxide/min./ml. enzyme preparation.

A stoichiometric relationship between stipitatonic acid removed, and carbon dioxide and stipitatic acid formed was established in the following manner. On incubation of 1 ml. of enzyme solution with 8·5 μmoles of stipitatonic acid, 6·25 μmoles of carbon dioxide were produced after 102 min. The flask contents were heated in a boiling water bath for 5 min. and a protein-free filtrate prepared. The stipitatonic acid remaining was found to be 2·2 μmoles. (The stipitatonic acid used as substrate in these experiments was extracted from *P. stipitatum* cultures by a method developed in this laboratory. The determination of stipitatonic acid was carried out by a spectrophotofluorometric method. Details of these procedures will be published separately.) Stipitatic acid formed was determined to be 6·3 μmoles by measuring the optical density of an aliquot at 275 mμ at *p*H 7 and correcting for that due to the stipitatonic acid remaining as previously determined. All values were corrected by use of a blank treated identically but containing no stipitatonic acid as substrate. With a boiled enzyme preparation and stipitatonic acid, no carbon dioxide was produced and the stipitatonic acid added was recovered.

Magnesium, zinc and manganese divalent ions added as the chlorides at a concentration of 10^{-4} *M* and cysteine, 10^{-3} *M*, were without effect on the decarboxylase activity while mercuric chloride, 10^{-5} *M* and 10^{-4} *M*, caused 25 per cent and 55 per cent inhibition, respectively.

The enzyme preparations, as well as decarboxylating stipitatonic acid, showed considerable decarboxylating activity towards a crude mixture of puberulic and puberulonic acids. Since there was no decarboxylation of pure puberulic acid, this must be presumed to represent a decarboxylation of the puberulonic component. Puberulic and puberulonic acids are not normal metabolites of *P. stipitatum* and it is not yet known whether the two decarboxylation activities are associated with the same enzyme. Work to purify the crude enzyme preparation and to characterize it further is now in progress.

It seems most likely that the pairs stipitatonic acid—stipitatic acid and puberulonic acid—puberulic acid are related biochemically through the action of

the tropolone dicarboxylic acid decarboxylase described here. Unless fixation of carbon dioxide is involved in formation of the carboxyl groups, and the previous isotope data do not support this possibility[1], it is clear that the precursors of stipitatonic and puberulonic acids must at least be C_9 compounds.

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Action of Ribonuclease on Nerve Axoplasm as Demonstrated by Silver Staining

IT was observed that crystalline ribonuclease selectively prevented demonstration of nerve axoplasm by a simple silver method reported elsewhere[1]. The tissue was treated with 0·01 per cent crystalline ribonuclease in distilled water at 60° C. for 1 hour. Ribonuclease was also observed to prevent axon staining as well as to alter the staining capacity of the Nissl substance and nucleoli of the spinal cord when the Bodian and toluidine blue methods were used.

Two lots of crystalline ribonuclease were used. The results were similar in the two instances. Both lots of enzyme had given negative reactions to standard tests for proteolytic activity. In addition, the enzyme was treated with ammonium sulphate heated at 100° C. after the procedure suggested by Swift[2], without change in the results obtained.

A series of inhibitors of the activity of ribonuclease was utilized. Sodium chloride, magnesium chloride, copper sulphate, phenylisocyanate and periodate, in concentrations published as inhibiting agents for ribonuclease, allowed silver staining of the axoplasm to occur. Control sections treated at 60° C. for an hour with ribonuclease alone showed no staining.

Extraction of formalin-fixed nerve tissue with 10 per cent perchloric acid for periods up to 24 hours did not change the stain. Extraction of Bouin-fixed material with trichloracetic acid at 90° C. for 30–60 minutes did remove the staining capacity of axoplasm.

The nature of the substance that permits silver staining of nerve tissue is not known. The action of ribonuclease points towards a nucleoprotein basis for staining. Purine and pyrimidine bases may bind silver as seen in the methods for urates. Silver purine compounds are used in the isolation and analysis of nucleic acid. The relation of formalin fixation to ribonuclease activity and other related problems are under investigation.

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ANIMAL PHYSIOLOGY

Active Transport of Uric Acid Through the Human Erythrocyte Membrane

Active Transport of Uric Acid Through the Human Erythrocyte Membrane

IN connexion with determinations of the uric acid pool in man by means of labelled uric acid, it has been repeatedly observed that it takes several hours before the injected uric acid reaches equilibrium in the total volume of distribution. This indicates that the cell membranes have a limited permeability to uric acid. It is known[1,2] that uric acid is able to penetrate the erythrocyte membrane of man. The ratio between uric acid/l. of red blood cells and uric acid/l. of plasma[3] is 0·55. The extra- and intracellular concentrations of uric acid in the water phase are nearly the same when correction is made for the Gibbs-Donnan effect.

We have now been able to demonstrate, that a part of the transport of uric acid into human erythrocytes is inhibited by hypoxanthine. These results, together with results from experiments employing variations in temperature, indicate that the system responsible for the transport of uric acid through the human erythrocyte membrane has two components. Furthermore, experiments carried out at different *p*H values, suggest that the uric acid crosses the erythrocyte membrane in its undissociated form.

Fresh heparinized blood was washed three times with isotonic phosphate buffer (0·11 *M*), *p*H 7·0 (unless otherwise indicated). The buffer contained 1 gm. of glucose per litre, and the same uric acid concentration as the original plasma to avoid fluctuations in the intracellular concentration of uric-acid. After washing, the red blood cells were suspended in the buffer, with or without addition of hypoxanthine, to give a final hæmatocrit of 50–60 per cent. After 15 min. equilibration at 22° C. (unless otherwise stated) and shaking, 1 μc. of uric acid-8-^{14}C (2·4 μc./μM) was added at zero time. The flasks contained a total volume of 24 ml. each. At different time-intervals, samples were taken, and the cells removed by centrifugation in the cold at 9,000*g*. The supernatant was measured for radioactivity, and from the decline in specific activity with time, the velocity of uric acid exchange was calculated.

Fig. 1 shows uric acid exchange as a function of hypoxanthine concentration. It can be seen that by increasing hypoxanthine concentrations, the uric

acid exchange decreases until 20 per cent of the control value is reached. From this point, increase in hypoxanthine concentration will give no additional inhibition. At hypoxanthine concentrations giving maximal inhibition, there is still a considerable exchange, thus indicating two mechanisms for uric acid transport: one sensitive to hypoxanthine, and another which accounts for the remaining transport at maximal hypoxanthine inhibition.

In order to obtain a further description of the two components of the transport system, we have investigated uric acid exchange under variations in *p*H and in temperature.

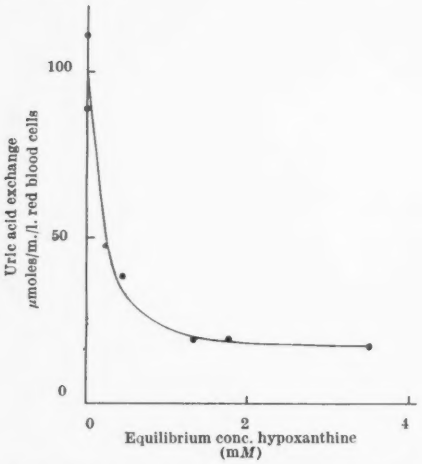

Fig. 1. Inhibitor action of hypoxanthine on uric acid exchange in human red blood cells

Table 1. Uric Acid Exchange in Human Blood Red Cells Suspended in Isotonic Phosphate Buffer at Different *p*H Values

*p*H	Calculated half-time for supernatant radioactivity (min.)	Uric acid exchange (μM/hr./l. red blood cells)	Undissociated uric acid (μM/l.) (supernatant)
7·15	13·9	273	3·33
7·58	32·5	116	1·55

Uric acid concentration 187 μM/l. of supernatant. Temperature 22° C. Hæmatokrit 60 per cent

Table 2. Influence of Temperature on Uric Acid Exchange in Human Red Blood Cells

Temperature (° C.)	Calculated half-time for supernatant radioactivity (min.)	Uric acid exchange (μM/hr./l. red blood cells)
37·0	8·9	485
16·5	52·1	82

Uric acid concentration 216 μM/l. of supernatant, *p*H 7·0. Hæmatocrit 60 per cent

From Table 1 it may be seen that uric acid transport was accelerated with decreasing *p*H. This increase in velocity could be accounted for by the increasing concentration of undissociated uric acid, indicating that undissociated uric acid may be the only form of uric acid able to be transported through the human erythrocyte membrane.

Results from experiments in which different temperatures were maintained are seen in Table 2, which shows that uric acid exchange increases from 82 μM/hr./l. red blood cells at 16·5° C. to 485 μM/hr./l. red blood cells at 37° C. showing that the velocity of uric acid exchange increased 2·8 times when temperature is increased 10° C. The corresponding value of simple diffusion in the same temperature interval is 0·035. This suggests that at least a part of the uric acid transport into the erythrocytes was undertaken by an active, probably enzymatic system.

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Effect of Pempidine on the *in vitro* Synthesis of Acetylcholine

Corne and Edge[1], working in these laboratories, found that large doses of pempidine (1 : 2 : 2 : 6 : 6-pentamethylpiperidine) a new ganglion-blocking agent used in the oral treatment of hypertension, caused some reduction in the output of acetylcholine from the perfused superior cervical ganglion of the cat during preganglionic stimulation. The reduction in output was insufficient to account for the complete block in transmission observed, nevertheless an investigation into the possible interference of pempidine with the *in vitro* synthesis of acetylcholine seemed worth while. It has already been shown that the inhibitory effect of pempidine on the breakdown of acetylcholine by acetylcholinesterase is of a low order and the drug cannot be classed as an active cholinesterase inhibitor such as physostigmine[1].

The experimental method adopted for studies on the synthesis of acetylcholine was similar to that used by Hebb[2] and is based on work by Korkes *et al.*[3] An extract of choline acetylase was prepared by suspending an acetone-powder of rabbit brain in cysteine-saline solution (3 mgm. cysteine/ml. of 0·9 per cent sodium chloride) in a concentration of 40 mgm./ml. This was stored in a frozen state in suitable aliquots and centrifuged at 2800 r.p.m. immediately before use. 0·1 ml. samples of the extract were incubated at 37° C. in a system containing 15–20 units of coenzyme *A*, 0·08 ml. of reaction mixture (containing equal parts of 4 per cent choline chloride and 30 per cent potassium chloride), 0·08 ml. of 1·2 per cent crystalline magnesium chloride, 0·14 ml. of 1 per cent acetyl phosphate*, 0·12 ml. of 3 per cent L-cysteine solution, 0·1 ml. of 0·25 per cent phosphotransacetylase* contained in 0·02 *M* potassium bicarbonate, 0·1 ml. of 0·1 per cent physostigmine and water to give a final volume of 1·0 ml. Pempidine and for comparison mecamylamine (3-methylamino*iso*camphane) were added to individual incubates to give final concentrations of $6{\cdot}4 \times 10^{-2}$ to 10^{-9} *M* and $6{\cdot}0 \times 10^{-2}$ to 10^{-9} *M*, respectively. The above constituents were incubated for 15 min. before the addition of the choline acetylase extract to allow acetyl-coenzyme *A* to form. One hour after the addition of the extract the reaction was stopped by boiling and the acetylcholine content of the acidified and diluted incubates was assayed on a frog rectus abdominis preparation[4].

At concentrations up to $6{\cdot}4 \times 10^{-3}$ *M* or $6{\cdot}0 \times 10^{-5}$ *M* neither pempidine nor mecamylamine, respectively, had any effect on the enzyme system which produced acetylcholine at a rate of 2·0–2·4 mgm./gm. of acetone powder/hr. The method of assay could not be applied when higher concentrations were used

because the drug inhibited the acetylcholine-induced contractions of the rectus abdominis muscle. This effect of direct action on the rectus muscle was in agreement with the findings of Corne and Edge[1] and of Stone *et al.*[5]

Gardiner's[6] experiments with a 'hemicholinium' compound (Scheuler's[7] compound No. 3, a hemiacetal containing a choline-like moiety) at a concentration of 10^{-4} *M* led him to believe that the compound does not inhibit choline acetylase as was first thought but acts on the system which transports choline into the cell and through the mitochondrial membrane. Preliminary work in this laboratory with whole homogenates and intact mitochondrial fractions prepared in the way described by Hebb[8] indicates that the same phenomenon is not true of pempidine and mecamylamine at concentrations of 10^{-5} *M*.

I am indebted to Dr. H. J. Barber and Dr. R. Wien for encouragement during this work.

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• Samples obtained from the Worthington Biochemical Corporation, Freehold, New Jersey, U.S.A.

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PLANT PHYSIOLOGY

A Kinin in Apple Fruitlets

Two challenging questions in developmental biology are the causes of the induction of cell division, and of the cessation of cell division. In plant tissues cell division may be aroused in response to treatment with diffusible substances collectively referred to as kinins[1]. One might enquire whether the meristems are self-perpetuating, through an ability to produce or accumulate such a kinin[2,3]. In asking this question our aim has been twofold: to learn whether the activation of the meristem is under the control of a diffusible substance, and to attempt to isolate and identify such a substance with the view of providing a means of chemically, and possibly commercially, controlling meristematic activity.

The known growth substances occur in minute concentrations in growing tissues. Since primary meristems are small, it would be impractical to try to obtain enough material of this kind to permit possible isolation and identification of an unknown kinin. As a more readily available source of bulk material, the apple 'fruitlet' was chosen. In the fleshy receptacle, the phases of cell division and cell enlargement are separate in time; up to three weeks after pollination growth is due to increase in cell number, after which cell division ceases and growth is due to cell enlargement[4–6].

Apples (*Pyrus malus*, variety Granny Smith) were harvested on October 31, 1958, approximately 14 days after pollination. They were 5–8 mm. in diameter and averaged 0·2 gm. in weight. The apples were pressure cooked for 2 min. at 18 lb./sq. in., macerated in water, filtered and the filtrate evaporated to dryness *in vacuo* below 40° C. The residue was taken up in basal medium[7].

Activities of the crude extract and of subsequent fractions were assayed by examining their ability to induce cell division in blocks of tobacco stem pith in the presence of 10^{-5} M indole-3-acetic acid.

Under these conditions, crude apple extract, at concentrations equivalent to 3, 10 or 30 gm. fresh tissue/100 ml. medium induced cell proliferation (Fig. 1). In the presence of indole-3-acetic acid alone, there was no cell division, but only cell enlargement. The response to 10 gm./100 ml. apple extract was earlier and greater than those due to optimal concentrations of kinetin (10^{-6} *M*) or coconut milk (6 per cent).

It appears that, as with kinetin, coconut milk, and immature maize endosperm, the apple extract requires the presence of auxin in order to act. When indole-3-acetic acid is omitted and the native auxin present is removed from the extract by shaking with ether at *p*H 3, no cell division is induced. Adding indole-3-acetic acid (10^{-5} *M*) restores the activity.

The kinin activity is not an artefact of autoclaving. This has been shown by making the original extraction in 70 per cent aqueous ethanol, concentrating to dryness *in vacuo* below room temperature under sterile conditions, taking up the residue in sterile basal medium containing 10^{-5} *M* indole-3-acetic acid and dispensing this solution into sterile assay vessels. Activity obtained was comparable with that of extracts made and sterilized by autoclaving.

Dissection of a quantity of fruitlets before making extracts revealed that the kinin activity resided mainly in the fleshy receptacle and to a much lesser extent, per fruitlet, in the ovules.

Disks of cortical tissue excised from receptacles of apple fruit no longer undergoing cell division have recently been stimulated to grow by resuming cell division under the influence of coconut milk kinin and an auxin[8]. We have repeated this work, and it has proved possible to replace coconut milk with the

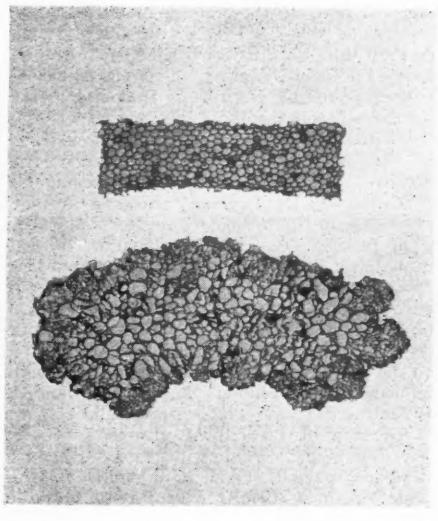

Fig. 1 Transections of blocks of tobacco stem pith incubated for 15 days (25°C.) on: *A*, basal medium; *B*, basal medium containing apple extract equivalent to 0·3 gm. fresh weight/ml., plus 10^{-5}*M* indole-3-acetic acid. Stained with ruthenium red

kinin of the apple fruitlet. Thus we may postulate that this kinin is responsible for the cell division occurring in the receptacle of the fruitlet.

Water extracts from larger apples (6–7 cm. diameter, 17 weeks after pollination) were tested at concentrations equivalent to 3, 10 and 30 gm. fresh tissue/100 ml. medium, and little if any activity was detected. Higher concentrations were toxic, so comparison with extracts from fruitlets on a per cell basis awaits purification of the extracts.

Work on the purification of the extract is proceeding.

The apples used were kindly provided by Dr. P. Geier, of the Division of Entomology, Canberra.

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Effects of Auxin and Gibberellic Acid on Growth of *Ulothrix*

The profound biological effects produced by indoleacetic acid and gibberellic acid, when applied to higher plants, have led many investigators to study their activity on algae. In general, the results of such experiments have not been striking. An excellent review of the literature concerning the effect of auxins on algae is to be found in the studies of Thimann and Beth[1]. These workers demonstrated a two-fold increase in stalk elongation of *Acetabularia* in the presence of 5×10^{-5} *M* indoleacetic acid. Further, they were able to show that cap formation was enhanced both in the intact as well as enucleated cells, a conclusive demonstration that indoleacetic acid acts directly on the cytoplasm.

We have discovered that a freshwater green alga, *Ulothrix subtillisima* Rabenh, No. 462, obtained from the Culture Collection of Algae, Department of Botany, University of Indiana, shows a dramatic growth response in the presence of either indoleacetic acid or gibberellic acid. An innoculum of cells, 0·7–1·0 mgm. air-dried weight, was transferred aseptically to 10 ml. of a sterilized modified Bristol's solution[2] in a 25-ml. culture tube. Indoleacetic acid and gibberellic acid (75 per cent pure) were obtained from Nutritional Biochemicals Corporation, and were added to the tubes in a small volume of distilled water to the concentration desired. The use of ethanol to dissolve the indoleacetic acid or gibberellic acid was avoided because of its known growth promoting effect on *Chlorella*[3,4]. The tubes were placed in inclined racks in front of the light source in order to provide optimal surface area for illumination. Three light sources were tested: (1) a single daylight fluorescent light emitting 25 foot candles at the surface of the alga, (2) a single incandescent bulb emitting 100 foot candles, and (3) normal sunlight from a southern exposure with care taken that sunlight did not fall directly on to the tubes. The artificial light was administered continuously; the sunlight was subject to normal diurnal variation with a maximum intensity of 700 foot candles. After 15 days the contents of each tube were passed through a tared membrane filter, rinsed with distilled water, air dried and weighed. Net increase in air-dried weight is reported. Each point on the graphs represents an average of two experiments.

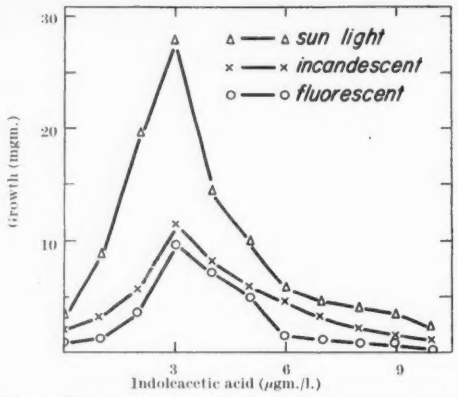

Fig. 1. The increase in growth of *Ulothrix* expressed as net increase in air-dried weight as a function of indole acetic acid concentration at three different intensities of illumination

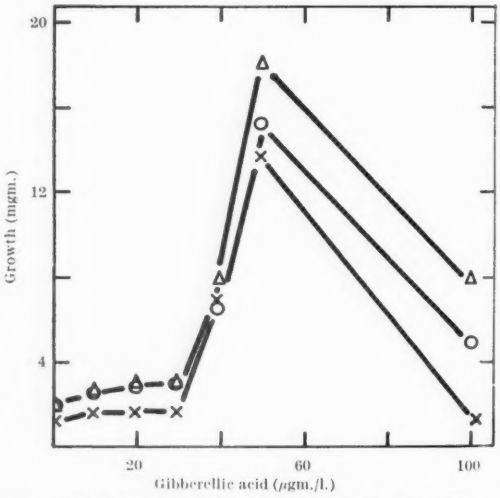

Fig. 2. The increase in growth of *Ulothrix* as a function of gibberellic acid concentration at three intensities of illumination. Symbols on graph are the same as in Fig. 1

The increase in growth of *Ulothrix* as a function of indoleacetic acid concentration is shown in Fig. 1. Under the three light conditions tested it can be seen that the optimal growth is obtained at 3 μgm./l. of indoleacetic acid. Higher concentrations of indoleacetic acid produced a characteristic inhibition of growth[5]. The thirteen-fold increase in air-dried weight under sunlight is to be noted. It appears that light intensity is a limiting factor for the cultures grown under artificial light.

The effect of gibberellic acid in growth is seen in Fig. 2. Although the growth at optimal gibberellic acid concentration is less than that observed for

indoleacetic acid, it is nevertheless, a seven-fold increase when compared with the controls. It should be remembered that the gibberellic acid used is only 75 per cent pure. Intensity and quality of light seem to have little effect on the gibberellic acid response. Similar effects, of less magnitude, have been reported by Provosoli using *Ulva*[6].

Microscopic examination of cells grown with indoleacetic acid and gibberellic revealed no appreciable change in either size or shape. However, there was an increased number of zoospores present. These findings support the concept that the growth substances accelerate cell division rather than cell elongation. Further investigations are in progress to elucidate the mechanisms by which indoleacetic acid and gibberellic acid stimulate the growth of *Ulothrix*.

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Influence of Kinetin, β-Indoleacetic Acid and Gibberellic Acid on Nuclease Activity of Bean (*Phaseolis vulgaris*) Hypocotyls

RECENTLY Skoog, Miller and co-workers[1] have drawn attention to the role of growth substances in nucleic acid synthesis connected with mitosis and cytokinesis. Silberger and Skoog[2] reported that treatment of tobacco pith with indoleacetic acid in sterile culture caused an increase in ribo- and deoxyribonucleic acids. Studies of the cytological effects of auxins and kinins in tobacco callus and stem tissue cultured *in vitro*[3] have shown that a delicate balance between indoleacetic acid and kinins may determine all types of growth from cell enlargement to organ formation. The biochemical nature of this interaction, especially its role in nucleic acid metabolism, remains to be determined. This communication deals with the influence of kinetin, indoleacetic acid and gibberellic acid on the activity of deoxyribonuclease and ribonuclease–enzymes concerned in nucleic acid metabolism.

Extracts of hypocotyls from 8–10 days old plants of dwarf bean (*Phaseolus vulgaris* var. Canadian Wonder), grown in the glass house in sand without added nutrients were used to determine enzyme activity. 2 gm. of fresh hypocotyls were ground with buffer solution (5 ml.) in a porcelain mortar and the extract squeezed out by hand through strong cotton cloth. The suspension was centrifuged at 1,500 *g* for 5 min., the green deposit removed and the clear supernatant fluid used as enzyme solution. Enzyme activities were measured by the methods described by Holden and Pirie[4]. 1 ml. of enzyme solution was used for deoxyribonuclease activity and 0·3 ml. for ribonuclease activity. The mixtures of enzyme solutions and substrates were incubated in 37° C. with or without solutions of kinetin, indoleacetic acid or gibberellic acid in a range of concentrations.

The results of typical experiments on kinetin and indoleacetic acid are shown in Tables 1 and 2, where

Table 1. THE INFLUENCE OF KINETIN AND INDOLEACETIC ACID ON RIBONUCLEASE ACTIVITY IN UNITS PER GM. FRESH TISSUE OF BEAN HYPOCOTYLS

Concentration of indoleacetic acid (μgm./l.)	Concentration of kinetin (μgm./l.)								
	0	10^{-3}	10^{-2}	0·1	1	10	10^{2}	10^{3}	10^{4}
0	6·6	6·4	7·8	9·3	9·3	9·5	7·4	4·0	3·8
10^{-3}	6·5	—	—	—	—	—	—	—	—
10^{-2}	6·7	—	—	—	—	—	—	—	—
0·1	6·2	6·6	6·8	9·2	9·0	8·9	6·0	3·6	4·0
1	6·4	—	—	9·5	9·8	9·2	—	—	—
10	6·5	6·8	8·0	12·3	12·3	12·5	6·5	6·8	4·4
10^{2}	5·5	7·0	8·0	8·2	8·2	9·0	7·0	4·2	4·0
10^{3}	4·4	6·4	8·2	9·5	8·8	7·3	6·5	5·0	3·8
10^{4}	4·4	—	—	—	—	—	—	—	—

Table 2. INFLUENCE OF KINETIN AND INDOLEACETIC ACID ON DEOXYRIBONUCLEASE ACTIVITY IN UNITS PER GM. FRESH TISSUE OF BEAN HYPOCOTYLS

Concentration of indoleacetic Acid (μgm./l.)	Concentration of kinetin (μgm./l.)				
	0	10	10^{2}	10^{3}	10^{4}
0	0·75	0·80	1·80	2·00	1·80
10	0·80	0·76	2·80	3·20	2·70
10^{2}	0·73	—	—	—	—
10^{3}	0·70	0·75	1·60	2·50	2·00
10^{4}	0·74	0·69	1·75	2·70	2·20

the enzyme activity is expressed in the units defined by Holden and Pirie[1]. There were strong interactions between kinetin and indoleacetic acid in their effects on the activities of both ribonuclease and deoxyribonuclease. Kinetin increased the activities of both enzymes when given alone and still more in presence of indoleacetic acid. The latter alone had no effect, but in presence of kinetin increased the enzyme activities. The maximum effect on ribonuclease occurred with concentrations of 0·1 to 10 μgm./l. of kinetin and 10 μgm./l. of indoleacetic acid, which nearly doubled the activity of the control. The maximum effect on deoxyribonuclease occurred with concentrations of 10^{3} μgm./l. of kinetin and 10 μg./l. of indoleacetic acid, which trebled the activity. Thus, kinetin was effective in much lower concentration on ribonuclease than on deoxyribonuclease. Other combinations of kinetin and indoleacetic acid supply had smaller effects, and the highest concentrations tested depressed ribonuclease activity.

Gibberelic acid did not stimulate the activities of deoxyribonuclease and ribonuclease, and at very high concentrations (10^{5} μgm./l.) slightly depressed both enzymes.

The interaction between kinetin and indoleacetic acid may be the biochemical basis of cytological effects noted by Das, Patau and Skoog[5], who found that some deoxyribonucleic acid was formed and some mitoses induced by kinetin without added indoleacetic acid. Conversely, a few cell divisions were induced by indoleacetic acid without added kinetin, whereas no cell division or mitosis was found when neither indoleacetic acid nor kinetin was added[3]. These slight effects were attributed by Skoog and Miller[1] to the small endogenous quantities of these substances. The bean extracts used in my experiments could be expected to contain small amounts of growth substances, but the results show that both kinetin and indoleacetic acid are required for optimal activities of deoxyribonuclease and ribonuclease.

The present results indicate that further biochemical studies of the role of growth substances as stimulants of nucleic acid metabolism would be profitable.

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BIOLOGY

Failure of Corpuscles of Stannius from Winter Flounder (*Pseudopleuronectes americanus*) to Synthesize Adrenocorticosteroids *in vitro*

The corpuscles of Stannius, supposedly endocrine glands, are peculiar to teleostean fishes. Their function is uncertain[1], but Rasquin[2] has suggested that they are concerned in osmoregulation. Unequivocal evidence that the interrenal tissue of teleosts is the homologue of the adrenal cortex[3,4] strongly suggests that a role other than production of corticosteroids be attributed to the corpuscles of Stannius. In order to supply direct evidence to support this assumption, procedures used in studies on interrenal tissue of *Fundulus heteroclitus*[4] were applied to corpuscles of Stannius collected from *Pseudo-pleuronectes americanus*. Sixty-one fish, caught in Niantic Bay and Long Island Sound, Conn., in December 1958 yielded 95 corpuscles of Stannius weighing 104·7 mgm. This tissue and 162 mgm. of mesonephric kidney which served as control tissue, were separately incubated with tritiated progesterone in a manner previously described[4].

Each medium was extracted twice with 1/2 vol. methylene chloride and the extract washed once with 1/10 vol. 0·05 *N* sodium hydroxide, twice with 1/10 vol. water, dried with *N* sodium sulphate, evaporated *in vacuo* and the dried residue applied to a paper chromatogram. Chromatographic separation followed in the toluene/propylene glycol system. The three areas corresponding to cortisol, cortisone, and corticosterone were eluted and rechromatographed in Bush *C* system. Four areas closely approximating the positions of cortisol, cortisone, aldosterone, and corticosterone, run in parallel, were eluted together with a paper blank from an area between the origin and cortisol. An aliquot from each eluate was taken for estimation of radioactivity. All areas, even from the controls, contained a small amount of the above background radioactivity. In order to determine whether or not the radioactivity could be accounted for by non-specific impurities, the remaining eluates from the various areas were dried down and applied to paper and chromatographed in the E_2B system[5]. Elution of the areas corresponding to cortisol, cortisone, corticosterone and aldosterone followed, and aliquots were again taken for estimation of radioactivity. Radioactivity in each area was equal to or lower than background radiation. It is concluded from this that the small amount of radioactivity from the previous chromatographic run was accounted for by non-specific impurities, and that within the limitations of the techniques employed the corpuscles of Stannius are not concerned with the production of adrenocorticosteroids.

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Rediscovery of *Bathynella chappuisi* Delachaux in Britain

In 1927 Lowndes discovered *Bathynella chappuisi* Delachaux in the Bath Oolite quarries at Corsham in Wiltshire[1]. Since 1932 this genus has not been reported from Britain although it and related genera have been recorded from the Continent[2] and Japan[3]. In February of this year, however, a single specimen of *Bathynella chappuisi* Delachaux was collected in some mud and sand taken from a spring-fed cattle trough in a pasture in Wytham Park, Berkshire. (Dr. I. Gordon of the British Museum has tentatively confirmed this identification.) Further collections, some made at night, have failed to produce any more specimens, although the common subterranean amphipod *Niphargus aquilex* Schiödte has turned up regularly.

Chappuis (in ref. 4) suggested that *Bathynella* occurred only by accident in wells, springs and streams and that the animals had been washed into these habitats from their normal ones, which he has shown to be in the interstitial spaces of the permanent water table. This seems to be the most likely explanation for the occurrence of this animal in a spring at Wytham, where it could have been washed out of the hill. The spring is one of a number situated between the 300- to 400-foot contours along the eastern edge of Wytham Hill. These springs rise between the Coral Rag and Wheatley Limestones above, and the Oxford Clay below. Between these is a thin edge of Lower Calcareous grit sand, the remains of a thicker layer, still present in the middle of the hill, that is slowly being washed away from under the Coral Rag cap[5]. The fine sand below a cap of Coral Rag may provide a suitable interstitial habitat for *B. chappuisi* and the continuous trickle of water from the soil above, down through the Coral Rag and out at the springs, may supply enough detritus to sustain a subterranean fauna. It seems unlikely that the animals are living in the pasture soil around the spring as it is very muddy and well trampled by cattle, but only by digging into the Calcareous Grit sand could it be confirmed that there is a permanent aquatic interstitial fauna.

This new record of *Bathynella* is of interest because it is the only known site of living members of the Syncarida in Britain, the original habitat having now almost certainly been destroyed.

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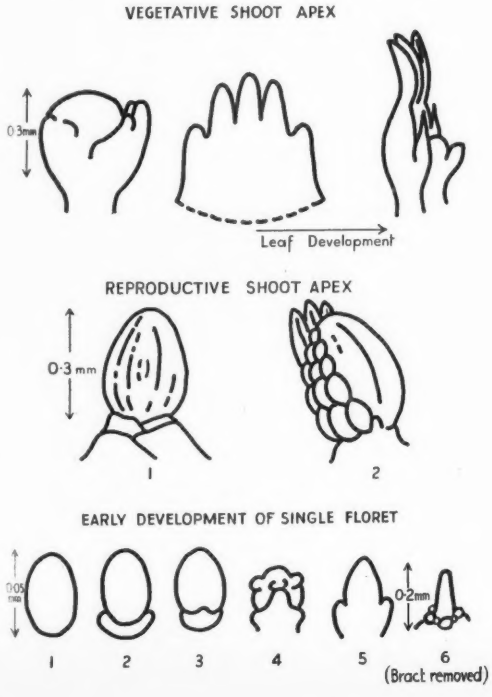
Floral Initiation and its Relationship to Growth-Stage in Red Clover (*Trifolium pratense* L.)

THE vegetative apex of red clover (*Trifolium pratense*, L.) is hemispherical, cutting off leaf initials by almost vertical divisions on alternate sides and producing internodes by basal elongation. At the beginning of floral initiation the apex enlarges and the florets then begin to appear as swellings near the base on the side proximal to the penultimate leaf. Each floret initial rapidly cuts off a bract initial which enlarges to cover the developing floret. The bract becomes hairy and if it is removed at this stage the developing ovary is exposed as a conical projection about 0·2 mm. in length, ringed at the base by cells which eventually develop to form the calyx, corolla, and nectaries. The pentamerous symmetry of the genus is apparent even at this early stage.



The production and extension of stem internodes as well as the formation of leaves, appears to be principally regulated by temperature and light intensity. This is instanced by the ability of Aberystwyth *S* 123 extra-late-flowering red clover to produce a large number of extended internodes when grown under non-inductive day-length conditions but in high light intensity and high temperature regimes.

Under favourable day-length conditions, floral initiation occurs after the production of a predetermined number of internodes, the apex enlarging to form a terminal head initial. No exposure to low temperature or short day appears to be necessary in this species. The day-length requirement for flowering varies widely, being about 12 hr. for early-flowering types and in the region of 15 hr. for late-flowering varieties. It can, therefore, be seen that the exact stage at which the apex ceases to be vegetative depends largely upon the variety in question and is the product of the interaction between genotype, temperature and photoperiodic conditions.

Under field conditions at Aberystwyth, English broad red clover which produces 6–7 extended internodes before heading, forms a terminal head initial when 1–2 are externally visible, usually in mid-April. Aberystwyth *S* 123, a late-flowering type producing 14–16 elongated internodes, shows no apparent change-over until 6–7 are externally visible, normally near the end of May.

In conclusion it is suggested that length of day rather than growth stage is the main factor determining the point at which floral structures are initiated.

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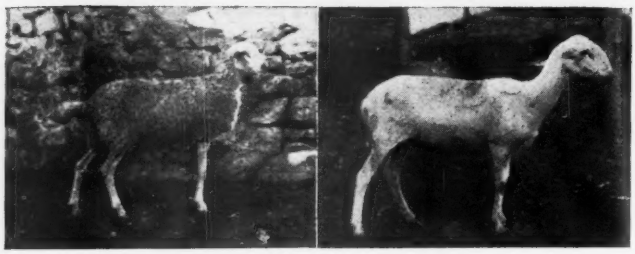
A Lesion of the Follicle and of the Fibre of Wool and its Possible Relation with an Excess of Iron in the Forage

IT HAS been observed that sheep which graze in certain regions of the Iberian Peninsula, for example, along the Iberian Cordillera and especially in the Maella zone[1,2], to which this work refers, lose their wool progressively (Fig. 1). Histological analysis shows that the folicular bundles separated by loose, very thin and elastic, connective tissue, assume at the beginning a slightly polygonal arrangement. As the alteration advances, they assume first a roundish shape and later an elongated one, until the follicles become completely independent (Fig. 2).

The degeneration of the follicles (Fig. 3) is closely associated with this process of modification of the follicular bundles. The secondary follicles are lost because of: (*a*) their projection towards the surface and lack of activity of the bulb in producing a Malpighian epithelial small duct; (*b*) follicular necrosis and atresia, while Henle and Huxley lamnæ become horny, and an empty space is formed in the follicle which becomes filled with remains of elastic connective tissue. The degenerative process can lead to an almost complete loss of these follicles. The primary follicles persist even when they have degenerated, as they are lost with difficulty. Their degeneration, which begins after that of the secondary follicles, takes the following course: (*a*) separ-

ation and isolation of the follicle, which becomes surrounded by connective tissue; (*b*) keratinization of Henle and Huxley laminæ in their lower part; (*c*) degeneration of the papilla of the bulb so that an atypical, completely void medulla is formed. Thefollicles producing this type of fibre (which replaces the wool fibre) remain thus enclosed in the derm. The epidermis decreases considerably in thickness and shows deep microscopic incisions because of the degeneration of the hair. The volume of the sebaceous glands is considerably reduced.



(*a*) (*b*)

Fig. 1. (*a*) Lamb six months old; (*b*) sheep 4 years olds.

The fact that animals born at Maella, taken immediately to other zones, grow normal fleeces during their whole life and, on the other hand, that sheep taken to Maella from other regions develop the alterations described above, indicate that this process is not due to genetic factors. Moreover, the flocks are kept on a régime of almost permanent grazing, and the soils at Maella have a skiletic and semi-desert character, with about 55 per cent calcium carbonate. The forage is provided by the association *Rosmarinus-Ericium*, typical of the Mediterranean region. The most frequent plant species are *Rosmarinus officinalis*, *Fumaria thymifolia*, *Brachypodium ramosum*, *Ononis tridentada*, *Thymus vulgaris* and *Cistus clusii*.

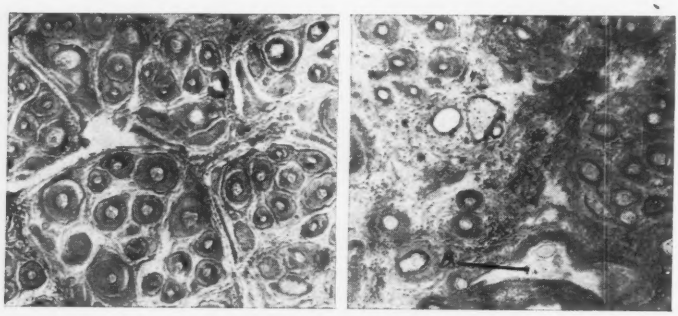
Table 1. Analysis of Soils and Forage from the Maella Region

	Soil	Forage
Sulphur	18 per cent	0·29 per cent
Iron	9,891 p.p.m.	1,026 p.p.m.
Molybdenum ..	0·95 p.p.m.	0·37 p.p.m.
Copper	21·16 p.p.m.	31 p.p.m.

Average of 24 samples of soil and 60 of forage.

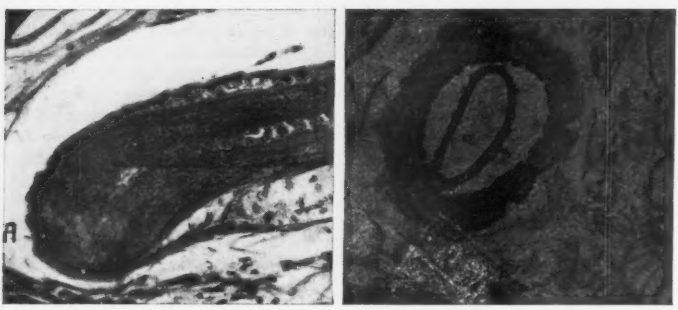
These circumstances have led us to consider a possible influence of nutritive factors. G. Gonzalez and J. Garcia[3] reviewed recently the food constituents which have been shown to influence the growth of wool. Of these we selected sulphur, copper, molybdenum and selenium for investigation.

Four groups of three lambs each were dosed by mouth during 14 months with 10 mgm. selenium (as sodium selenite), group *A*; 30 mgm. molybdenum (as ammonium molybdate), group *B*; 10 mgm. selenium + 8 gm. potassium sulphate, group *C*; and 30 mgm. molybdenum + 10 mgm. copper (as copper sulphate), group *D*; a fifth group was kept as control. After the first seven months the molybdenum of the groups *B* and *D* was raised from 30 to 90 mgm. daily. It was found that 30 mgm. of molybdenum daily as ammonium molybdate do not produce any alteration in the weight and characteristics of the fleece and wool fibre; 90 mgm. molybdenum daily provokes a slight diminution of the absolute and relative resistence, and of the extensibility of the wool fibre. Also, this amount of molybdenum produces a loss of crimp in some of the animals, but not in all of this group. The addition of 10 mgm. copper, as copper sulphate, to the 90 mgm. molybdate counteract these effects. In the selenium groups *A* and *C*, the results showed no variation in the weight of the fleece, in the absolute and relative length, or in the crimp and mechanical properties of the wool fibre compared with the controls[4].



(*a*) (*b*)

Fig. 2. (*a*) Follicular arrangement in perfect polygonal shape, typical of crossed sheep; (*b*) Isolation of wool hairs. Appearance of skin folds, *A*.



(*a*) (*b*)

Fig. 3. (*a*) Degeneration starting at the base of the wool follicle, *A*; (*b*) Premature keratinization of the cuticle of the sheath and of the cuticle of the fibre, with loss of the medullary structure of the fibre.

On the other hand, the composition of the soil and of the vegetation, shown in Table 1, indicates an outstanding fact, namely, the abnormally high iron content. In contrast with normal values for sulphur, molybdenum, manganese and copper, the average values obtained for iron were: 1,026 p.p.m. in soils and 9,891 p.p.m. in the forage, the ranges being

32–2,060 and 4,400–20,000, respectively. High values were obtained even after the plants analysed had been washed to eliminate soil particles.

The histo-chemical analysis of hides of sheep from Maella during the degenerative process showed, by means of a Perls reaction, that there is a large quantity of iron in the sweat glands as well as in the cuticle of the sheath and fibre and in the epithelial scales; this is drawn up by the growing fibres and comes out at the surface.

The possible effects on sheep of ingesting abnormally large quantities of iron, on the general metabolism and the formation of the wool fibre, are under investigation and the results will be published elsewhere.

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PATHOLOGY

Geology and Multiple Sclerosis

Most areas where there is a high prevalence of multiple sclerosis coincide in a highly suggestive fashion with areas where glaciation has played an important part in providing parent material for soils. However, the converse is certainly not true: all glacial soils cannot be correlated with areas where the prevalence of multiple sclerosis is high. Maps showing the distribution of multiple sclerotic cases in Northern Ireland, south-eastern Ontario, Sweden, and Denmark are alike in one respect—they all bear a remarkable resemblance to maps illustrating the distribution of boulders or geochemical anomalies in any map prepared for the purpose of searching in a glaciated area for buried ore bodies.

A consideration of some epidemiological maps reveals the following facts. In Scandinavia and northern Scotland, where on the whole the prevalence of multiple sclerosis is high, there are at least five 'islands' where it is significantly low, namely, (1) Gävleborg province north of Gävle, Sweden, (2) Södermanland province, Sweden, (3) large sections of Holland, Göteborg and Bohus Provinces, Sweden, (4) the Norwegian coastal provinces of Rogaland, Hordaland, Sogn og Fjordane, and Møre og Ramsdale, (5) the Outer Hebrides of Scotland. With the solitary exception of Rogaland and southern Hordaland all the above areas are substantially underlaid by old gneisses, which in a general map of Scandinavia are mapped as being similar. Conversely, if we note areas where prevalence is high, we find an entirely different set of geological formations, namely, in Norway and Sweden either Eocambrian sediments or granitic rocks, and in northern Scotland by Old Red Sandstones and granitic rocks.

In North America I have seen few distribution maps indicating the prevalence of the disease; but it is generally considered to be high in south-western Quebec, the southern part of Ontario, and in central Nova Scotia. In all these areas there are abundant limestones, in places dolomitic, and some granitic rocks.

One other point appears worthy of note: higher than 'normal' quantities of lead are known to occur in those rocks referred to above as occurring in areas where the prevalence of multiple sclerosis is high. The Eocambrian sediments of Norway and Sweden, some granites in Telemark, Norway, the Old Red Sandstones of northern Scotland, and many of the limestones of southern Quebec, Ontario, and central Nova Scotia are all known to contain significant, although not necessarily commercial, amounts of lead. Similar rocks in the north-eastern United States and southern Manitoba may likewise be assumed to carry lead. It should also be noted that anomalous amounts of lead may, on occasion, be accompanied by anomalous amounts of some other elements such as silver, barium, magnesium, and fluorine.

These observations are founded on the published work and personal communications of many workers in the fields of medicine and geology. Acknowledgement will be made to these authors in a paper now being prepared for publication.

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Department of Geology and Geography, University of British Columbia, Vancouver, 8. June 1.

An Experimental Enterococcal Pyelonephritis in Mice

In the course of studying the animal pathogenicity of various bacterial species obtained from human infections, we noted that certain strains of enterococci localized and persisted in the kidneys of mice subsequent to intravenous challenge. Moreover, this enterococcal pyelonephritis could be induced with regularity in mice simply by intravenous injection, and did not require kidney traumatization as described by Braude *et al.*[1] for the initiation of enterococcal kidney disease in rats. Since enterococci, particularly *Streptococcus faecalis*, are frequently associated with urinary tract infections in man[2,3] we felt that it would be pertinent to conduct further experiments on the murine disease. This communication presents our initial observations on certain bacteriological aspects of experimental enterococcal pyelonephritis. Additional results, including the histopathological characteristics of this mouse infection, will be reported elsewhere.

The strain of *Str. faecalis*, designated '*MGH-2*', which was employed in our studies was submitted by Dr. B. A. Waisbren of the Milwaukee County General Hospital, Wisconsin, shortly after its isolation from the urine of a patient. This organism was maintained on ordinary blood agar and apparently did not require passage through mice to sustain its virulence. The growth from a 6–8 hr. culture in trypticase soy broth at 37° C. was diluted with an equal volume of saline, and 0·2 ml. was injected into the dorsal tail vein of each mouse. Male, albino *CF*-1 mice, 4–5 weeks old and weighing approximately 16 gm., were used in the

experiments. At various daily and weekly intervals following this challenge, groups of mice were killed and the extent of enterococcal involvement was estimated by performing replicate plate counts of macerated, weighed organs. Bacterial counts were also made on measured volumes of blood, and, in general, these enterococci appeared to exist as pairs and short chains in the blood and the various tissues which were cultured.

Although we observed little evidence of gross pathology in any organ, an impressive extent of bacterial invasion of the kidneys was a constant finding throughout the observation period. More than 90 per cent of the kidneys contained numerous enterococci when we examined them at various intervals up through 24 days after challenge. Yet, despite this degree of kidney involvement, there was only a 5 per cent mortality within this period. The low number of deaths and the absence of obvious pathology indicated that the renal disease had attained a host-parasite equilibrium, and therefore was quite chronic. A similar chronicity, it may be noted, appears also to characterize enterococcal pyelonephritis in man[4,5].

Subsequent to these initial experiments, more definitive studies were undertaken, wherein larger numbers of mice were infected and a more prolonged observation period (152 days) was employed. Mice selected randomly as groups of 10 were killed at frequent intervals and bacterial plate counts were made of tissue and blood specimens taken from each group. On these occasions, all the livers taken from the mice were pooled and homogenized, and similar pools were prepared from the heart blood and the spleen, lungs, and kidneys. In this manner, we obtained only an average estimate of the number of cocci per gram of organ tissue and per ml. of blood at each time-interval. Thus, the extent of variation in bacterial involvement between different mice was not determined in these particular experiments.

The graphs presented in Fig. 1 illustrate the changes in bacterial numbers found in the blood, lungs, spleen, liver, and kidneys during the 152 days of observation following challenge. In all tissues but the kidneys, it was apparent that an initial seeding occurred during the first 24 hr., followed by varying rates of elimination thereafter. A minor coccæmia persisted for about 14 days which more likely represented a release of cocci from the lungs and spleen than a true blood infection. Enterococci could not be recovered from the lungs and spleen after 21 days, nor from the liver after 57 days. Grossly, none of these three organs exhibited any overt pathology.

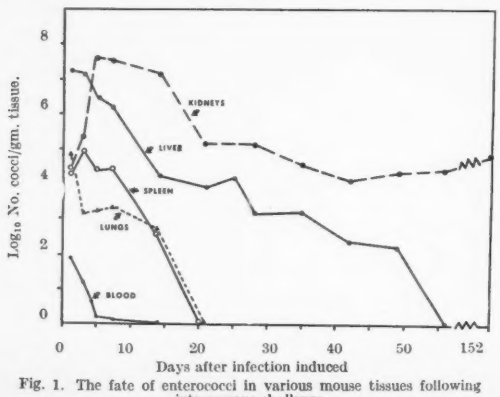

Fig. 1. The fate of enterococci in various mouse tissues following intravenous challenge

In contrast to the above, the kidneys provided a much different picture. As shown in Fig. 1, there was a fairly rapid increase in numbers of cocci during the first 5 days to a maximum population of nearly 10^8 per gm. of kidney. This peak-level was followed by a moderate decline during the next 15 days, and, 20 days after challenge, a fairly constant bacterial concentration of about 10^5 cells per gm. persisted throughout the entire 152-day period. Except for some pallor and an occasional minute surface lesion, the kidneys appeared grossly to be free of significant pathology. However, our colleagues who are examining tissue sections taken from these mice have indicated that a considerable amount of microscopic pathology had occurred. Their observations and conclusions, as previously mentioned, will be published on completion.

Another observation merits mention at this time. During certain additional experiments on the chemotherapy of this infection, a spontaneous superinfection of the renal tissues with a strain of *Aerobacter aerogenes* was noted in 15–20 per cent of the animals. This superinfection occurred only when mice were treated with those agents which effected a limited eradication of the enterococci. It did not occur, however, in untreated mice or in mice treated with an agent highly effective against the enterococci. This strain of *A. aerogenes* will be employed in further experiments to study the nature of spontaneous and experimental superinfections. For the present, this observation is noted in order to submit a further example of the resemblance which appears to exist between the 'natural' human and this experimental enterococcal pyelonephritis[3].

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June 16.

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Effect of Thiouracil and Thyroxine on Development and Growth of Cutaneous Melanoma in Killifish Hybrids

Conflicting results have been obtained concerning the influence of the thyroid gland on the development and the growth of tumours in mammals and man.

Recently Meites, Trainin and Berenblum[1] performed an experiment with an inbred strain of Swiss mice, in which urethane was given once, followed by thrice weekly paintings of the skin with croton oil. The development of skin tumours was inhibited by the co-administration of thyroxine and enhanced by thiouracil.

Later Meites[2] studied the effects of feeding 2 mgm. of thyroxine or 2 gm. of thiouracil/kgm. diet on induction of skin tumours in young female *CF* Swiss mice. The tumours were induced by one 0·05-ml. application of 0·25, 0·50, or 1 per cent of 9, 10-dimethyl-1, 2-benzanthracene, to the back of each mouse, was followed by weekly paintings with 5 per cent of croton oil in liquid paraffin for 16 or 17 weeks.

In the mice fed thyroxine the tumour incidence, the average number of tumours per tumour-bearing

Table 1

	Thiouracil		Thyroxine		Controls	
	No. of fishes	Average body weight (gm.)	No. of fishes	Average body weight (gm.)	No. of fishes	Average body weight (gm.)
Start of expt.	30	1·02	30	1·06	30	1·04
after 190 days	30	2·05	30	2·16	30	2·12
Days after beginning of expt.	No. of fishes with tumour	Total tumours/group	No. of fishes with tumour	Total tumours/group	No. of fishes with tumour	Total tumours/group
50	3	5	0	0	1	1
70	7	17	0	0	3	4
90	16	35	0	0	7	15
110	20	59	1	1	10	21
130	23	85	1	1	16	34
150	25	108	2	2	19	50
170	27	134	3	4	21	59
190	30	155	5	6	21	65
	Average tumour surface area (sq. mm.)	Average No. tumours/tumour fish	Average tumour surface area (sq. mm.)	Average No. tumours/tumour fish	Average tumour surface area (sq. mm.)	Average No. tumours/tumour fish
	18·6 ± 4·4	5·2	1·4 ± 0·3	1·2	11·1 ± 2·5	3·1
	Average latent period	Days after beginning of expt. to first tumour	Average latent period	Days after beginning of expt. to first tumour	Average latent period	Days after beginning of expt. to first tumour
	70–90	30	190	110	110–130	450
	Fishes with tumour regressions		Fishes with tumour regressions		Fishes with tumour regressions	
	0		3		0	

mouse and the average surface tumour area showed a significant reduction; there was an increase with the mice fed thiouracil.

We have studied the influence of the thyroid-gland on the development and the growth of a tumour in a lower vertebrate: the cutaneous melanoma of killifish hybrids.

For the experiments female hybrids *Xiphophorus helleri* Heckel × *Xiphophorus maculatus* Günther were used, from three litters of inbred strain with a high tumour incidence. The fishes, which were 380 days old at the beginning of the experiment, were divided into three groups, each of thirty animals. The first groups received thiouracil, thyroxine, and normal food respectively.

The thiouracil on the thyroxine was mixed with the food in concentrations of 2 gm. per kgm. and 2 mgm. per kgm., respectively. The food was composed according to the directions of Gordon[3].

The feeding of the fishes started at the beginning of the experiment. The body-weight was measured once in twenty days. The fishes were kept in small glass tanks with tap water (Utrecht) at a temperature of 28° C.

As soon as the tumours began to appear, the location and the size of the tumours were also measured every twenty days. Neither tumours less than 0·5 mm. in diameter nor melanomas which regressed before the 50th day were recorded. At the end of the experiment the diameters of the tumours were measured in the living fishes, whereby the total tumour cross-sectional area of tumour per tumour-bearing fish was calculated.

The results of the experiment are summarized in Table 1. At the end of the experiment the average body-weights of the fishes of the three groups were about the same. During the first 110 days of the experiment the fishes fed thyroxine consistently gained on the fishes of the thiouracil and control groups.

Furthermore 30 of the 30 thiouracil-fed fishes had 155 tumours, that is an average of 5·2 tumours per tumour-bearing fish. Only 5 of the 30 thyroxine-treated fishes had 6 tumours, that is, an average of 1·2 tumours per tumour-bearing fish. 21 of the 30 control fishes had 65 tumours, that is, an average of 3·1 tumours per tumour-bearing fish.

Compared with the control animals the average tumour surface area showed a significant increase in the fishes fed thiouracil and in the thyroxine-fed fishes a significant reduction.

Tumours were first observed on fishes fed thiouracil on the 30th day after the beginning of the experiment, on the fishes fed thyroxine on the 110th day, and on the control animals on the 50th day.

The tumours of three fishes which were fed with thyroxine, appeared to regress completely within 74, 92 and 118 days, respectively. Many of the melanomas in the thiouracil-fed fishes increased in size during the experiment, whereas in the tumours of fishes fed thyroxine little if any increase in size was observed. Also the control animals showed a considerable increase in size.

On the strength of this experiment I conclude that the development and the growth of the cutaneous melanoma of the killifish hybrids is enhanced by thiouracil and inhibited by thyroxine. Consequently, hyperthyroidism as well as hypothyroidism influences tumour formation.

These results are completely in agreement with those of Meites, Trainin and Berenblum[1] and of Meites[2] for Swiss mice of an inbred strain.

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May 11.

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Tumour Specificity and Immunological Suppression

Antisera toxic for tumours but innocuous for normal tissues have been sought with meagre or questionable success since the early days of immunology. The outcome of most experiments has emphasized the antigenic similarities rather than the disparities between normal and tumour cells so that the existence of tumour-specific antigens has remained entirely hypothetical. Indeed, it would seem rather

hopeless to resume the search for tumour-specific antigens were it not for two circumstances. The first of these is the work of Zil'ber[1,2] and others in the U.S.S.R. who by means of anaphylactic reactions in the guinea pig have provided strong evidence for the existence of tumour-specific antigens. The second is the phenomenon of immunological suppression, including acquired tolerance for homologous transplants[3] and suppression of specific antibody response[4] by the introduction of tissues or simple antigens into embryonic or early post-natal mammals. The present experiments were based on the assumption that if one could suppress antibody formation against normal tissues, as suggested by the work of Feldman and Yaffee[5], it might be possible to produce antibodies directed exclusively against the specific antigens of tumours—providing such antigens exist. Our results thus far encourage the conclusion that the immunologically suppressed animal provides the long-sought means of producing antisera capable of discriminating between tumours and normal tissues.

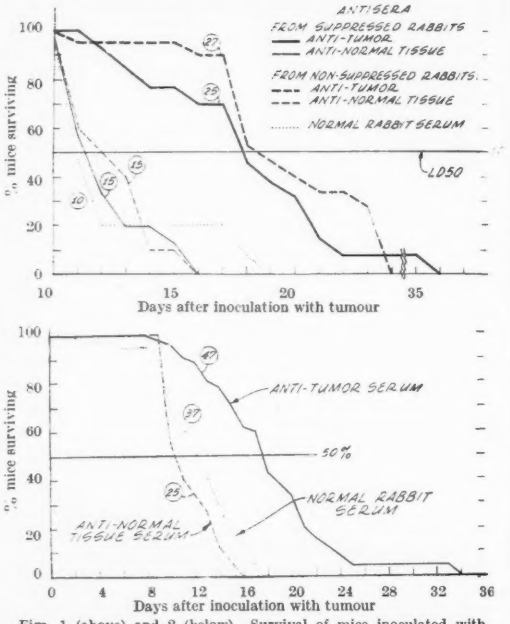
The Ehrlich ascites tumour was used and maintained in closely inbred *C3H* mice. The tumour is antigenically so like the normal tissues of *C3H* mice that antisera directed against it are also highly toxic for the normal mouse. The production of antisera of increased toxicity for the Ehrlich tumour without corresponding toxicity for normal *C3H* tissues was demonstrated by the following four-step method.

(1) Within 12 hr. after birth New Zealand and Dutch rabbits were given the first of a series of suppressing injections composed of homogenized normal tissues (unperfused spleen, liver, lung, thymus, and mammary gland) taken from 24 or more mice. Injections were then continued for 21 days, each animal receiving a total of 1·55–1·98 gm. wet weight of homogenate containing 389–496 mgm. protein. Uninjected litter mates served as controls.

At 12 weeks of age sera from the injected (presumptively suppressed) animals and from the controls were injected into mice inoculated with a standard dose of Ehrlich ascites tumour. Neither type of serum had any perceptible influence on the growth of the tumour, which killed the mice within the usual time (*LD* 50, 12 days). Skin tests were carried out on the rabbits by injecting supernatants from the normal tissue homogenate and the Ehrlich tumour. 8 of the 11 presumptive suppressed rabbits showed no cutaneous reaction.

(2) The 11 presumptive suppressed rabbits and 6 normal controls were then injected intraperitoneally with 200 mgm. wet weight of the same normal tissue homogenate previously injected with the aim of suppressing the antibody response. The 3 rabbits with positive skin test and one with negative skin died 8–12 days after injection, with autopsy findings indicative of serum sickness. Sera obtained from the survivors at 5 and 14 days after injection were tested in tumour-inoculated mice and showed no effect upon the growth of the tumour as indicated by the average survival time of the mice. Skin tests of the rabbits, using supernatants from both normal and tumour tissue, were now negative in all suppressed rabbits and mildly positive in the 6 controls.

(3) The suppressed rabbits, which had by this time failed to show anti-tumour sera in two successive tests, were now divided into two groups: (*A*) Three rabbits received each a total of 280 mgm. protein of normal tissue homogenate and (*B*) four rabbits received each 260 mgm. protein of tumour. The normal (non-suppressed) rabbits received equivalent amounts of



Figs. 1 (above) and 2 (below). Survival of mice inoculated with Ehrlich ascites tumour, after a single dose of rabbit antiserum administered shortly after the tumour. In Fig. 2 the results using anti-tumour and anti-normal tissue sera are grouped together irrespective of their origin in suppressed or non-suppressed rabbits.

(*C*) normal tissue and (*D*) tumour. The amounts of tissue indicated were distributed among 6 injections given on alternate days. All rabbits were bled on the 5th and 14th days after the last injection and the sera used fresh or stored at 4–6° C. without preservative. The antisera obtained at 14 days were tested for anti-tumour activity by injection of 0·2 ml. intraperitoneally per mouse inoculated one-half hour previously with a standard tumour dose (8×10^6 cells in 0·2 ml.).

As shown in Fig. 1, the single dose of anti-tumour serum, whether from suppressed or non-suppressed rabbits, protected the mice to a significant degree. On the other hand, antisera against normal tissues had little effect or seemed to decrease survival in comparison with controls given normal rabbit serum or saline. The reproducibility of these results is indicated by another experiment summarized in Fig. 2, in which

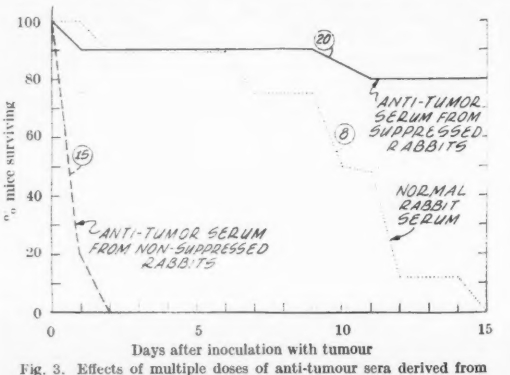

ANTI-TUMOR SERUM FROM SUPPRESSED RABBITS
NORMAL RABBIT SERUM
ANTI-TUMOR SERUM FROM NON-SUPPRESSED RABBITS
% mice surviving
Days after inoculation with tumour

Fig. 3. Effects of multiple doses of anti-tumour sera derived from suppressed or non-suppressed rabbits upon the survival of tumour-inoculated mice

mice receiving anti-tumour or anti-normal sera are grouped together, irrespective of the origin of the sera from suppressed or non-suppressed animals. The tendency of anti-normal sera to decrease survival is again evident.

(4) The striking advantage in the use of anti-tumour sera produced by suppressed animals is shown in Fig. 3. In this experiment multiple doses of serum were given in the attempt to enhance the survival of tumour-inoculated mice. Three doses each of 0·4 ml. were injected during the first few days after inoculating the tumour, and in some instances, depending on survival, three others on days 7, 8, and 9. The antisera from non-suppressed rabbits proved uniformly lethal within 48 hr.; since the tumour never kills mice within this short period, death must be attributed to the toxicity of the antiserum for *C3H* mice, a conclusion supported by autopsy. Mice receiving normal rabbit serum were all dead within 15 days, with abdomens distended by tumour growth. In contrast, mice receiving anti-tumour sera produced by suppressed rabbits showed 80 per cent survival on the 16th day.

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An Effect of Dose Fractionation on the Incidence of Bone Tumours using Radioactive Phosphorus

CARCINOGENIC studies with rats using 'bone seeking' radioactive isotopes have shown that if the isotope is administered in several doses at intervals from a few days to one month a larger number of bone tumours develop than for a single injection of the same quantity of isotope[1,2]. This increase in the number of tumours is due to an increase in the probability of tumours developing and also to a reduction in the mortality of the rats from other causes both before and after the time of appearance of the first tumour.

Similar results have been obtained using radioactive phosphorus, phosphorus-32, (Bensted *et al.*, to be published). With this isotope, the injection of 1·0 μc./gm. body-weight followed by five doses of 0·6 μc./gm. (total dose 4 μc./gm.) at intervals of two weeks resulted in 13 rats in a group of 15 developing bone tumours, Fig. 1*a*. The two rats without tumours died at three months, one while under ether anæsthesia. The tumours appeared between 26 weeks and 39 weeks after the first injection and a high proportion of the animals had more than one tumour.

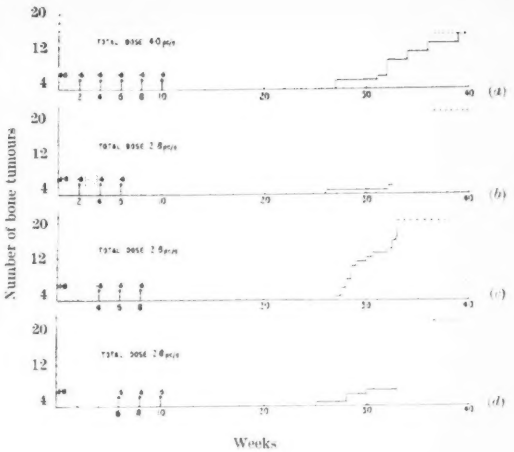

Fig. 1

In order to determine to what extent the various repeated injections contribute to the increased tumour incidence, a smaller total dose of 2·8 μc./gm. phosphorus-32 was administered as 1·0 μc./gm. followed by three injections of 0·6 μc./gm. In one group of 20 rats these injections, each of 0·6 μc./gm., were given at 2, 4 and 6 weeks respectively after the first injection. In a second group of 20 rats the injections were given at 4, 6 and 8 weeks and in a third group at 6, 8 and 10 weeks. The times of appearance of bone tumours are shown in Fig. 1*b*, 1*c* and 1*d*. At 30 weeks the number of tumours in the three groups of 20 rats was 1, 10 and 4 respectively and at 33 weeks 3, 17 and 4. This demonstrates that the mean time of tumour development may be altered considerably by changes in the timing of the injections for the same total dose of phosphorus-32. Since tumours are still appearing in the surviving animals it is not yet possible to say whether there will be a difference in the final tumour incidence. Up to date of these 60 animals only one rat has died without developing a tumour; this animal was in the second group of rats and the death occurred after the second injection before there was any reasonable possibility of a tumour having developed. The present data are not sufficient to determine the effectiveness of the individual injections in producing bone tumours. Nevertheless, they do suggest that injections at 4, 6 and 8 weeks after the first injection are particularly effective while those at 2 and 10 weeks have little effect or may even inhibit tumour formation.

Discussion of the results solely in terms of the timing of the injections is likely to be superficial since the distribution of the radiation dose within the bone varies in a complex manner with the timing of the injections. These complexities arise in part from the non-uniform distribution of the isotope and the continued growth of bone during the period of injection. The type and number of cells being irradiated at any particular time will also depend on the amount of previous damage produced and on the extent to which repair mechanisms are operating. In order to investigate these effects further, the distribution of the radiation dose in bone is being determined by means of 'thick section' autoradiography. The histological changes occurring with the different dosage

schemes are also being studied and will be reported elsewhere.

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BACTERIOLOGY

Distribution of Nucleic Acids among Different Stable *L* Forms of *Proteus P* 18

In previous work, we have studied some enzymatic activities of various morphological kinds of stable *L* forms derived from *Proteus P* 18 (ref. 1). These enzymatic activities were highest in the fraction of small size (fraction 3, 1·9–3·8 μ) and lowest or absent in fraction 4 (≦ 0·95 μ) containing the smallest forms invisible with the phase-contrast microscope.

We decided to inquire into the distribution of ribo- and deoxyribonucleic acids in the various *L* forms separated by differential ultra-centrifugation. Four groups of different sizes were used: fraction 1, 7·6–11·4 μ; fraction 2, 3·8–7·6 μ; fraction 3, 1·9–3·8 μ; fraction 4, ≦ 0·95 μ (ref. 2).

L forms are grown suspended in a hypertonic medium by a technique already described[3]. After separation of the particles of different sizes[2], the micro-organisms are freeze-dried and crushed in cold ether. In the case of fraction 4, we examined separately the whole fraction and the fraction passing through a Chamberland 3*L*3 filter. The acid-soluble phosphorus is removed by 7 per cent trichloracetic acid and the lipids are extracted by Bloor's method. The residue is hydrolysed using Schmidt and Thannhauser's technique[4]. In the acid-insoluble fraction of the alkaline digest, deoxyribonucleotides are extracted by normal perchloric acid at 80° C. during 30 min. and deoxyribose is essayed by the Burton modification[5] of Dische's technique[6]. In the acid-soluble part of the alkaline digest, ribonucleotides are determined by the orcinol procedure of Bial modified by Mejbaum[7]. The results were confirmed by the use of phloroglucinol[8] and assay of ribonucleic acid phosphorus after adsorption of the ribonucleotides on a charcoal column followed by elution with alcohol-ammonia.

Results are given for nuclear phosphorus (Table 1). The reference curve for deoxypentose has been established with a thymus deoxyribonucleic acid purified to Kay, Simmons and Dounce's methods[9], that of ribose with a yeast ribonucleic acid purified by Smith and Markham's method[10].

Table 1 shows that fraction 3 has the highest ribonucleic acid content: 1943 ± 125 μgm. phosphorus; then come fractions 2 (1418 ± 222 μgm.) and 1 (1132 ± 99·7 μgm.), followed by fraction 4 obtained by centrifugation (439 ± 81·7 μgm.) and finally fraction 4 by filtration (285 ± 28·3 μgm.)

The deoxyribonucleic acid content is highest in fractions 1 (520 ± 40·9 μgm.) and 2 (485 ± 75·1 μgm.),

Table 1. Distribution of Nucleic Acids among Different L Forms of *Proteus P* 18 Bacillus.
Results are reported in μgm. of phosphorus for 100 mgm. of delipidated weight.

	Ribonucleic acid phosphorus	Deoxyribonucleic acid phosphorus	Col. 2/Col. 3
Whole	1459 ± 41·95	515 ± 19·13	2·83 ± 0·19
Fraction 1	1132 ± 99·7	520 ± 40·9	2·18 ± 0·14
Fraction 2	1418 ± 222	485 ± 75·1	2·93 ± 0·41
Fraction 3	1943 ± 125	71 ± 7·8	27·2 ± 1·73
Fraction 4	439 ± 81·7	61 ± 6·4	7·22 ± 0·35
Fraction 4 filtrated	285 ± 28·3	389 ± 21·5	0·73 ± 0·05

much lower in fractions 3 (71 ± 7·8 μgm.) and 4 (61 ± 6·4 μgm.). In contrast, there is a high deoxyribonucleic acid in those elements of fraction 4 which pass through the Chamberland filter (389 ± 21·5 μgm.). It follows that the ratio of ribo- to deoxyribonucleic acid is lowest in the filtered fraction 4 (0·73 ± 0·05) which shows the lowest enzymatic activity. The ratio is highest in fraction 3 (27·2 ± 1·73) which possesses the highest enzymatic activity[1].

In summary, the distribution of ribo- and deoxyribonucleic acids differs in *L* forms of different sizes. It is noteworthy that the ratio of ribo- to deoxyribonucleic acid is highest in fraction 3 which is enzymatically very active and lowest in the filtered fraction 4. However, what is most striking is the high deoxyribonucleic acid content in the filtered particles of fraction 4.

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ANIMAL PSYCHOLOGY

Effect of a Signal Contingent upon an Avoidance Response

Conventional shock-avoidance training usually takes the form signal-shock-response which becomes signal-response when the appropriate behaviour is learned. This operant technique has been shown to produce faster learning than the classical procedure in which the unconditioned stimulus (shock) inevitably follows the conditioned response[1,2] and is most effective when the response terminates the signal as well as avoids the shock[3,4].

Under this latter condition two events occur: an exteroceptive stimulus change precedes a potentially noxious event, and an exteroceptive stimulus change follows the response which escapes from or avoids this event. These changes are almost invariably the onset and offset of the same stimulus. It is widely thought that both these events are necessary for successful avoidance learning to come about[5,6]. The stimulus onset preceding shock is said either to arouse fear, or to become aversive, and the stimulus offset contingent upon the response is said to be reinforcing, either by virtue of reducing fear or simply through the removal of the aversive stimulus.

It has been shown, however, that avoidance responses can be learned when there is no exteroceptive stimulus change contingent upon these responses[5]. On the other hand, Kamin[4] has demonstrated that avoidance learning is the poorer the greater the time-interval between the response and the offset of the warning stimulus, and has interpreted this finding in terms of delay of secondary reward. It is equally reasonable, however, to interpret his results by reference to the degree of stimulus change contingent upon the response.

It is possible to fractionate the discriminatory and reinforcing effects of the termination of a warning signal by introducing a second stimulus contingent upon the occurrence of an avoidance response, while leaving the original stimulus unaltered for a certain period. To this effect we utilized a procedure similar to that of Kamin except that a second stimulus came on when an avoidance response was made, and was terminated at the same time as the warning stimulus. Twenty-four naive male albino rats from 90–120 days old were divided into four equal groups (I, II, III, IV) and trained to avoid shock (110 V., 100 kΩ limiting resistance) by turning a small treadmill within 5 sec. after the onset of a weak light. Each animal was trained in a single session until it made two avoidance responses. Inter-trial interval times were 50, 60 or 70 sec. according to a predetermined random schedule, with a mean of 60 sec.

When shock was not avoided the escape response terminated both shock and light immediately for all animals. When shock was avoided by experimental animals (groups I and II) the avoidance response turned on a buzzer. Both light and buzzer were terminated after about 0·5 sec. for group I, and after 10 sec. for group II. No buzzer accompanied avoidance responses made by groups III and IV. The light was terminated immediately after these responses for group III, and after 10 sec. for group IV.

Table 1

Animal	First avoidance	Trials between	Animal	First avoidance	Trials between
I 2	9	1	III 2	5	1
I 2	6	4	III 2	6	1
I 3	5	1	III 3	31	1
I 4	30	3	III 4	5	1
I 5	4	0	III 5	9	3
I 6	6	1	III 6	4	0
II 1	9	0	IV 1	4	3
II 2	2	0	IV 2	6	16
II 3	8	0	IV 3	9	15
II 4	6	0	IV 4	13	4
II 5	17	5	IV 5	4	0
II 6	2	0	IV 6	6	2

In the 'Animal' column Roman numerals refer to training groups, Arabic numerals to the individual animals in those groups. 'First avoidance' is the trial of which the first avoidance response was made, and 'Trials between' is the number of escape trials between the first and second avoidance responses made by the respective animals.

Within the first ten trials behaviour was 'shaped' to facilitate escape learning, that is to say, shock was terminated when an animal approached the treadmill irrespective of whether it turned it or not. All animals learned to escape promptly within these ten trials, and thereafter only treadmill turning served to avoid or escape from shock. Spontaneous inter-trial responses were allowed, but served no purpose.

Table 1 shows the trial on which each animal made its first avoidance response, and the number of subsequent trials prior to the second avoidance of shock. As differential treatment between the groups began when shock was first avoided, the number of shocks between the first and second avoidance responses provides a measure of the effect of one application of the differential treatment. Such a measure is the cleanest test of the effect of post-avoidance conditions because behaviour on subsequent trials is a consequence of a mixture of shock and no-shock trials temporally distributed in different ways for different animals[4]. Application of the Mann–Whitney *U*-test to the results in Table 1 yields the following conclusions: (*a*) there is no significant difference between the four groups on the number of trials to the first avoidance response, (*b*) significantly fewer ($P < 0{\cdot}05$, one tail) shocks intervened between the first two avoidance responses of the animals in group III than between those of the group IV animals, (*c*) significantly fewer ($P < 0{\cdot}05$, one tail) shocks intervened between the first two avoidance responses of the animals in group II than between those of the group IV animals, and (*d*) the number of shocks between the first and second avoidance responses of the animals in groups I and II do not differ significantly.

As there were no significant differences between the trials to first avoidance between the four groups it is supposed that no systematic variations between the groups occurred prior to this point. The fact that significantly fewer shock trials intervened between the first and second avoidance responses when these responses immediately terminated the pre-shock signal than when the offset of this signal was delayed by 10 sec. confirms earlier findings that immediate termination of a warning signal facilitates avoidance learning. The finding that this difference vanishes when a second signal immediately follows the avoidance response in both cases suggests that the effects of different delays before termination of the warning signal are not directly dependent on this event. Those animals given a buzzer immediately after making an avoidance response performed equally well whether the pre-shock stimulus was immediately terminated or not. The superiority of the 10-sec. delay group with buzzer over the 10-sec. delay group without buzzer leads to the same conclusion.

Although avoidance learning is facilitated by the termination of the warning stimulus contingent upon the performance of the correct response it is not the termination of this stimulus *per se* that is crucial but the changed stimulus conditions after the response has been made. The effects upon the efficiency of avoidance learning seem to be about the same whether avoidance behaviour changes the pre-response stimulus itself or not, so long as some stimulus change

follows the response. Avoidance behaviour cannot, therefore, be simply interpreted in terms of the secondary reinforcing effects of the removal of an exteroceptive warning stimulus, but must make reference to the stimulus compound both before and after a response is made.

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ARCHAEOLOGY

Pleistocene Climatic Significance of Calcretes and Ferricretes

Calcretes and ferricretes are widespread features of African soils. They have attracted attention from both soil specialists and archæologists, for they frequently occur in soil profiles containing Stone Age artefacts and fossils. The calcretes and ferricretes have been generally assumed to have climatic and stratigraphic significance. Archæologists and geologists have dated them in terms of associated artefacts or fossils, just as other geological horizons are dated by *in situ* cultural or organic objects. R. F. Flint[1] has summarized recent views on the climatic interpretation of ferricretes and calcretes. Flint suggests that ferricrete formation requires rainfall 'above a certain minimum', stating that ferricretes "seem to indicate Pleistocene climates that were wetter than those of to-day, provided Pleistocene age is established", while calcretes imply low rainfall, perhaps less than 18 in. (45·6 cm.) per annum.

An interpretation of this kind was given to the soil profile at the Skoonheid 1529 Later Pleistocene archæological site, long. 29° 27′ E., lat. 24° 7′ S., 40 miles (64·7 km.) east of Potgietersrus in the Central Transvaal. Here an erosion gulley has exposed Stone Age artefacts in a way frequently found in Africa. A number of archæologists and geologists agreed with the observation and climatic deductions set out by one of us[2], but soil specialists found they could not accept the interpretation. Accordingly, we returned to the site in May–June 1959 for a fortnight's field study. We excavated a number of sections in the gulley and examined borehole profiles drilled for the purpose adjacent to the gulley.

The excavations showed that ferricrete concretions are scattered throughout the profile, though they are concentrated in the horizons given in ref. 2. Contrary to the views expressed there, these 'ferruginized zones' have no Pleistocene stratigraphic or climatic significance. For example, "Ferruginised Zone 2" both underlies and overlies the same Pleistocene Stone Age horizon at different parts of the site. "Ferruginized Zones 2 and 3" must have formed recently, when the entire soil profile was established but before erosion of the present gulley. The occurrence of all "ferruginized zones" at the site in Stone Age horizons is purely coincidental, for they formed tens of thousands of years later than the dates of the artefacts they encase.

Ferricrete may be seen actively forming in some parts of the gulley floor to-day, where water seepage along the granite bed-rock surface is producing a sesquioxide sheet or ferricrete in the overlying permeable sediments under impeded local drainage[3]. This recent ferricrete has cemented ancient Earlier Stone Age gravel in other parts of the site, thus—assuming a quite misleading age. Elsewhere on the site, excavation proved that the same gulley floor ferricrete, named "Ferruginized Zone 1" in ref. 2, lies several feet above the Earlier Stone Age gravels, clearly showing its more recent origin. In ref. 2 it was assumed that "Ferruginized Zone 1" formed immediately after Earlier Stone Age but its origin post-dates formation of the present gulley. In June 1959, at the height of the local dry season, ferricrete concretions appeared to be forming continuously in one part of the gulley floor where nocturnal water seepage to the surface ceased during the day.

Like ferricrete concretions, calcrete concretions also occur throughout the profile, but not in the limited horizons stated in ref. 2. Calcrete formation has continued in the less permeable horizons throughout the history of the profile, from Earlier Stone Age times to the present day, concurrently with ferricrete formation. To-day the area receives 21 in. (53·25 cm.) of rainfall per annum, while daily average temperature varies from 80° F. (27° C.) to 36·6° F. (2·6° C.), so at Skoonheid it is clear that ferricretes and calcretes reflect soil climate, not external climate. Wet conditions are necessary for the formation of ferricretes, but these occur within the soil itself, not above it. Soil evidence at Skoonheid 1529 therefore gives new evidence of the wide range of variation of conditions favouring ferricrete and calcrete development. Finally, study of the stratigraphy of the site in relation to present river action in the nearby Chunies River suggests that sedimentation on the site may have been controlled by the nearby gap in the Strydpoort Mountains known as Chuniespoort, and need have no relation to Pleistocene climatic change. The climatic interpretations and correlations set out in ref. 2 are accordingly withdrawn. The Pleistocene climatic and stratigraphic value of the calcretes and ferricretes at the Skoonheid 1529 profile have now been placed in truer perspective. There is little doubt that archæological interpretations of these features elsewhere in Africa should be reviewed in this light.

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